1983 CB ANNUAL REPORT

SUMMARY OF DEVELOPMENT ACTIVITIES, COSTS AND ENVIRONMENTAL MONITORING

CATHEDRAL BLUFFS SHALE OIL COMPANY

751 HORIZON COURT

GRAND JUNCTION, COLORADO 81501

APRIL 30, 1984

Cathedral Bluffs Shale Oil Company
P.O. Box 2687, Grand Junction, Colorado 81502-2687

1983 CB ANNUAL REPORT

SUMMARY OF DEVELOPMENT ACTIVITIES, COSTS AND ENVIRONMENTAL MONITORING

April 30, 1984

Submitted by:

CATHEDRAL BLUFFS SHALE OIL COMPANY
751 Horizon Court
Grand Junction, Colorado 81501

to:

Mr. Lee Carie
Craig District Manager
U.S. Bureau of Land Management
131 N. 6th Street - Suite 300
Grand Junction, Colorado 81501

COLOR INFRARED PHOTOGRAPH OF THE C-b TRACT VICINITY
(SCALE 1:58,000)

FOREWORD

The 1983 CB ANNUAL REPORT is submitted to fulfill the requirements of Oil Shale Lease Number C-20341 as stated in Section 16(b) of the Lease, Section 1.(C)(4) of the Lease Environmental Stipulations, and Condition of Approval No. 3 of the Detailed Development Plan issued on August 30, 1977.

See Section 9.3.2 for further discussion of the Frontispiece.

TABLE OF CONTENTS

1983 CB Annual Report

Summary of Development Activities, Costs and Environmental Monitoring

TABLE OF CONTENTS (Cont'd)

[illegible]

TABLE OF CONTENTS (Cont'd)

[illegible]

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF TABLES (Cont'd)

LIST OF FIGURES

[illegible]

LIST OF FIGURES (Cont'd)

Page No.

[illegible]

LIST OF FIGURES (Cont'd)

[illegible]

[illegible]

[illegible]

SUMMARY OF DEVELOPMENT ACTIVITIES, COSTS AND ENVIRONMENTAL MONITORING

1.0 INTRODUCTION AND SUMMARY

This report summarizes the development activities, costs, and environmental monitoring on the Federal Oil Shale Lease Tract C-b during calendar year 1983. The Tract is leased to Cathedral Bluffs Shale Oil Company under U.S. Department of the Interior Lease Number C-20341. It is managed by the equal-interest partnership between Occidental Oil Shale, Inc. and Tenneco Shale Oil Company, doing business as Cathedral Bluffs Shale Oil Company. The Tract is located in Rio Blanco County in the Piceance Creek basin of northwestern Colorado.

In January of 1983, CB submitted a proposal for financial assistance to the U.S. Synthetic Fuels Corporation (SFC) in response to their Third Solicitation. On July 28, 1983, the SFC announced it had signed a Letter of Intent to provide up to $2.19 billion in loan and price guarantees to the Project. CB now anticipates reaching a final agreement with the SFC in mid-1984. Nothing in the SFC agreement is intended to be in conflict with or to abrogate the directives of the Oil Shale Project Office. The CB Project is intended to produce approximately 14,100 barrels per calendar day (BPCD) of a commercial crude oil substitute. The Project includes mining, a commercial aboveground retort (AGR) using Union Oil Company's Unishale B process, four continuously burning modified in situ (MIS) retorts using the MIS technology developed by Occidental Oil Shale, Inc., an upgrading facility for treatment of raw shale oil, an approximate 46 mile pipeline and terminal and incidental facilities.

Additionally, in 1983 Project Level II/Level III Design and Cost Estimates were made for the mining and surface processing facilities.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Project expenditures in 1983 were approximately $14,477,000.

Principal activities on-Tract in 1983 were the commissioning of the production, service and auxiliary hoists, the continued water management program to treat and dispose of excess waters associated with mine dewatering and routine facility maintenance. No new structures were completed in 1983.

With regard to the geotechnical program, a bulk sample of high grade oil shale was mined in 1983 on the upper level station near the service shaft (see Figure 4-8). Approximately 1,200 tons of rock were mined in two stages. The first activity involved obtaining a very high grade sample to test the Union pilot retort's ability to process high grade feeds. The second mining activity obtained a coarse shale sample which was used to determine fines generation during size reduction by a feeder breaker. Additionally, as part of this geotechnical program, 6 core holes were drilled to provide additional core and gas production data in the proposed initial room and pillar and MIS mining areas and to provide additional hydrologic data and monitoring wells.

Water make for the shafts was as follows:

Shaft	Total for 1983 (million gal)	Cumulative Total To Date (million gal)
Ventilation/Escape	0	679
Production and Service	231.5	1044
TOTAL	231.5 (291)	1723* (1492)

Quantities for 1982 are shown in parantheses.

* An additional 19 million gal have been pumped from small wells for on-Tract use bringing the grand total to 1742 million gal.

The approved inactivation of the Ventilation/Escape (V/E) Shaft dewatering system in September 1981 continued thru 1982 and 1983.

The 1983 water management was achieved via direct discharge from on-Tract holding ponds under the NPDES permit. Following the inactivation of the V/E Shaft and subsequent declines in dewatering rates the reinjection mode was temporarily discontinued in July 1982. To summarize for the year 1983:

218.5	million	gal were discharged,
0	"	gal were reinjected,
0	"	gal were sprinkler irrigated,
12.8	"	gal were used or stored,
0.2	"	gal were lost to evaporation and seepage, and
231.5	million	gal were pumped.

The areas of new disturbance in 1983 consisted of the six drill pads of the geotechnical core sampling program. Each pad is approximately one-half acre in size, for a total of three acres of new disturbance bringing the total to 191 acres (less than 4% of the Tract).

Regarding environmental and health protection and control, in addition to water management already discussed, the following should be noted:

- Regarding air emissions, the cement batch plant ceased operation in 1982 and remained out of operation in 1983.

- No degradation in visual range has been noted since inception of the visibility program in 1975.

- A 9,000 gal/day capacity sewage treatment plan ceased operation in March of 1982 and remained out of operation in 1983. At present, the sewage is being disposed via porta-johns, and an approved sewage system that has been in operation for eight years is utilized to dispose of that from the C-b offices.

- 2 reportable accidents in 156,135 man hours on-Tract resulted in an accident incident rate of 2.56.

- Special reflectors, installed along four one-mile sections of Piceance Creek Road in 1981 as a mitigation test to reduce deer road kill, continued to be used thru 1982 and 1983. No statistical conclusions can yet be drawn on effectiveness of the reflectors although fewer deer are killed where reflectors are used.

Regarding socioeconomic impacts, the 1982 work force on Tract decreased from a year-end level of 30 in 1982 to a year-end level of 20 in 1983. Total persons employed directly by CB, including Grand Junction staff, decreased slightly from 67 in January to 64 in December. In mid November, CB submitted a Major Development Permit Application to Rio Blanco County. This included a proposal to construct a temporary on-site housing facility to house a portion of the Project construction employees. It includes a mix of recreation vehicle space and motel sytle units with a maximum of 850 dwellling units. The Application also contained a comprehensive socioeconomic impact assessment based upon the current development schedule. The preparation of this analysis involved discussions concerning potential socioeconomic impacts and mitigation strategies with sixteen local government jurisdictions in Rio Blanco and Garfield Counties. CB continued to participate in the Cumulative Impacts Task Force, an organization of local government, state government and industry, working to identify the cumulative socioeconomic effects of the energy industry.

Environmental monitoring has continued as an ongoing activity at the Tract since the completion of the two-year Baseline period (1974-1976). It encompasses air, water, and biology as well as studies of ecosystem interrelationships, toxicology, and health and safety. Results are summarized in Section 9 of this volume. No significant environmental impacts have been noted to date except for areas directly disturbed by drilling, construction, ponds, and mined rock disposal, drawdown of groundwater levels from mine dewatering, some vegetation effects in previously sprinkler-irrigated areas, and increasing fluoride values in one spring.

This Annual Report serves to demonstrate compliance with the Detailed Development Plan (DDP), the Development Monitoring Plan (DMP) (both of which imply compliance with the Lease), and the Water Court Decree #W-3492, leading to the Water Augmentation Plan (WAP). A Requirements Compliance Matrix is presented in Table 1-1 showing where information relating to these controlling documents is addressed in the Annual Report and in the semiannual environmental data reports.

The following project abbreviations appear in this report:

CB - for Cathedral Bluffs, and
C-b - for Colorado-b Federal Oil Shale Lease Tract.

TABLE 1-1

Requirements Compliance Matrix

Controlling Document	Document Section	Section Subject	Annual Report Section or Chapter	Semi-Annual Data Report Section or Chapter	Comments
DDP*	Volume I Section I	General Information and Summary	1, 2, 4, 7.11, 9		
	Section II	Phase I - Mine Development			
	A.	Schedule & Summary	3, 4		
	B.	Manpower	1, 8		
	C.	Engineering Design & Procurement	3.2, 4, 5		
	D.	Mine Surface Facilities	1, 3, 4		
	E.	Mine Shaft Sinking	1, 3, 4, 7.7		
	F.	Development Mine			
	G.	Utilities and Fuel	4, 7.3, 7.9		
	H.	Crushing and Conveying			
	I.	Alternate Mining Methods			
	J.	Access and Service Roads	4, 7.9		
	K.	Dams	7.2		
	L.	Coarse-Ore Conveyor & Stockpile			
	M.	Shaft Dewatering, Treatment & Disposal	4.1.10, 7.2	1.2.1, 1.2.2	
	Section III	Phase II - Plant Construction	5		
	A.	Summary	4		
	B.	Schedule & Manpower	3, 8		
	C.	On-Tract Surface Facilities	4		
	D.	Off-Tract Facilities	4		
	Section IV	Phase III & Phase IV			Not at this Phase of Development yet.
	A.	Summary - Phase III			" " " " " " "
	B.	Schedules and Manpower			" " " " " " "
	C.	Mine Operations			" " " " " " "
	D.	Crushing and Conveying			" " " " " " "
	E.	Retorting and Upgrading			" " " " " " "
	F.	Waste Disposal			" " " " " " "
	G.	Water Use			" " " " " " "
	H.	Electric Power Use			" " " " " " "
	I.	Utility Systems			" " " " " " "
	J.	Pipelines			" " " " " " "
	K.	Phase IV - Post Operations	7.10		" " " " " " "

*The DDP is required by the C-b Lease. These items are, in turn, required by the DDP.

TABLE 1-1 (Contd)

Controlling Document	Document Section	Section Subject	Annual Report Section or Chapter	Semi-Annual Data Report Section or Chapter	Comments
DDP*	Section V	Environmental Control Plans	1, 7, 9		
	A.	Air Pollution Control	7.1		
	B.	Water Pollution Control	1, 4.5, 7.2		
	C.	Noise Control	7.7.2, 9.3.7		
	D.	Protection of Historic, Scientific & Aesthetic Values	7.6, 9.3.13		
	E.	Fire Prevention & Control	1, 7.7.3		
	F.	Health and Safety	1, 7.7, 9.3.14, 9.3.13		
	G.	Overburden Management	6		
	H.	Processed - Shale Disposal	6		
	I.	Disposal of Other Wastes	4, 6, 7.4		
	J.	Fish and Wildlife Management	7.8, 9.3.4, 9.3.8		
	K.	Erosion Control and Surface Rehabilitation and Revegetation	6, 7.5, 9.3.10		
	L.	SPCC Plan	7.3		
	M.	Off-Tract Corridors	4.2.5, 7.9		
	Section VI	Environmental Monitoring			
	A.	Introduction	1, 9		
	B.	Soils Survey and Productivity Assessment	9	1.5.5	
	C.	Surface Water	1, 7.2, 9.3.3	1.2.1, 1.2.2	
	D.	Sub-surface Water	1, 7.2, 9.3.3	1.2.1, 1.2.2	
	E.	Meteorology and Air Quality	1, 7.1, 9.3.5,9.3.6	1.3, 2.1	
	F.	Biological	1, 6, 7.8, 9.3.4, 9.3.8, 9.3.9, 9.3.10	1.5	
	G.	Noise	7.7.2, 9.3.7	1.4	
DMP	Section 1	Introduction	2, 9.1, 9.2		
	2	Milestones & Maps	3.1, 9.2, 9.3		
	3	Photography		1.1	
	3.1	Surface	1	1.1	
	3.2	Aerial	1, 4.3.10, 9.3.2	1.1	
	Section 4	Indicator Variables	1, 9.3.1, 9.3.16		
	5	Hydrology			
	5.2	Surface	1, 4, 7.2, 9.3.3	1.2, 1.2.1, 1.2.2	
	5.3	Sub-Surface	1, 4, 7.2, 9.3.3	1.2.1, 1.2.2	
	5.4	Development	1, 4, 7.2	1.2.1, 1.2.2	

*Footnote, Page 1 of 3

TABLE I-1 (Contd)

Controlling Document	Document Section	Section Subject	Annual Report Section or Chapter	Semi-Annual Data Report Section or Chapter	Comments
DMP	Section 5.5	Systems Dependent	1, 4, 7.2		
	5.6	Quality Assurance	1, 9.3.16	1.2.3	
	6	Air Quality & Meteorology			
	6.2	Ambient Air Quality	1, 7.1, 9.3.5	1.3, 1.3.1, 1.3.3, 1.3.7	
	6.3	Meteorology	1, 7.1, 9.3.6	1.3.2, 1.3.7	
	6.4	Development - Related	1, 7.1		
	6.5	Systems Dependent	1		
	6.6	Quality Assurance	1, 9.3.16	1.3.6	
	7	Noise	1, 7.7.2, 9.3.7	1.4	
	8	Biology	1, 6, 9.3.4, 9.3.8, 9.3.9, 9.3.10	1.5	
	8.2	Big Game - Deer	1, 9.3.8	1.5.1	
	8.3	Medium Sized Mammals	1, 9.3.8	1.5.1	
	8.4	Small Mammals	1, 9.3.8	1.5.1	
	8.5	Avifauna	1, 9.3.8	1.5.1	
	8.6	Aquatic	1, 9.3.4	1.5.2	
	8.7	Terrestrial Veg.	1, 9.3.9	1.5.4	
	8.8	Threatened & Endangered	1, 9.3.8	1.5.3	
	8.9	Revegetation	1, 6, 9.3.10	1.5.5	
	8.10	Systems Dependent	1	1.5.6	
	Section 9	Items of Historic, Prehistoric or Scientific Interest	1, 9.3.13		
	10	Industrial Health & Safety	1, 7.7, 9.3.14, 9.3.15	1.6	
	11	Subsidence Monitoring			
	12	Ecosystem Interrelationships	9.3.10		
	13	Data Management & Reporting	9.1, 9.3.16, 9.3.17	3.0	
Water Court Decree W-3492	7	Legal Description of Site	2		
	8	Sources of Water Supply	4.1.10, 9.3.3		
	9, 10, 11	Dewatering & Augmentation	7.2, 9.3.3	1.2.1, 1.2.2	
	25	Monitoring Program Requirements for Evidence of Depletion Effects	7.2, 9.3.3	1.2.1, 1.2.2	Exhibit A, wells, springs, seeps, streams, precipitation sites. Exhibit B, Development Monitoring Program.
	26	Timely Implementation Requirement		1.2.1, 1.2.2	
	27	Tracking Cone of Depression	9.3.3	1.2.1	
	29	Cone of Depression Determination & Monitoring via Stream Flows, Correlations, etc.	9.3.3		

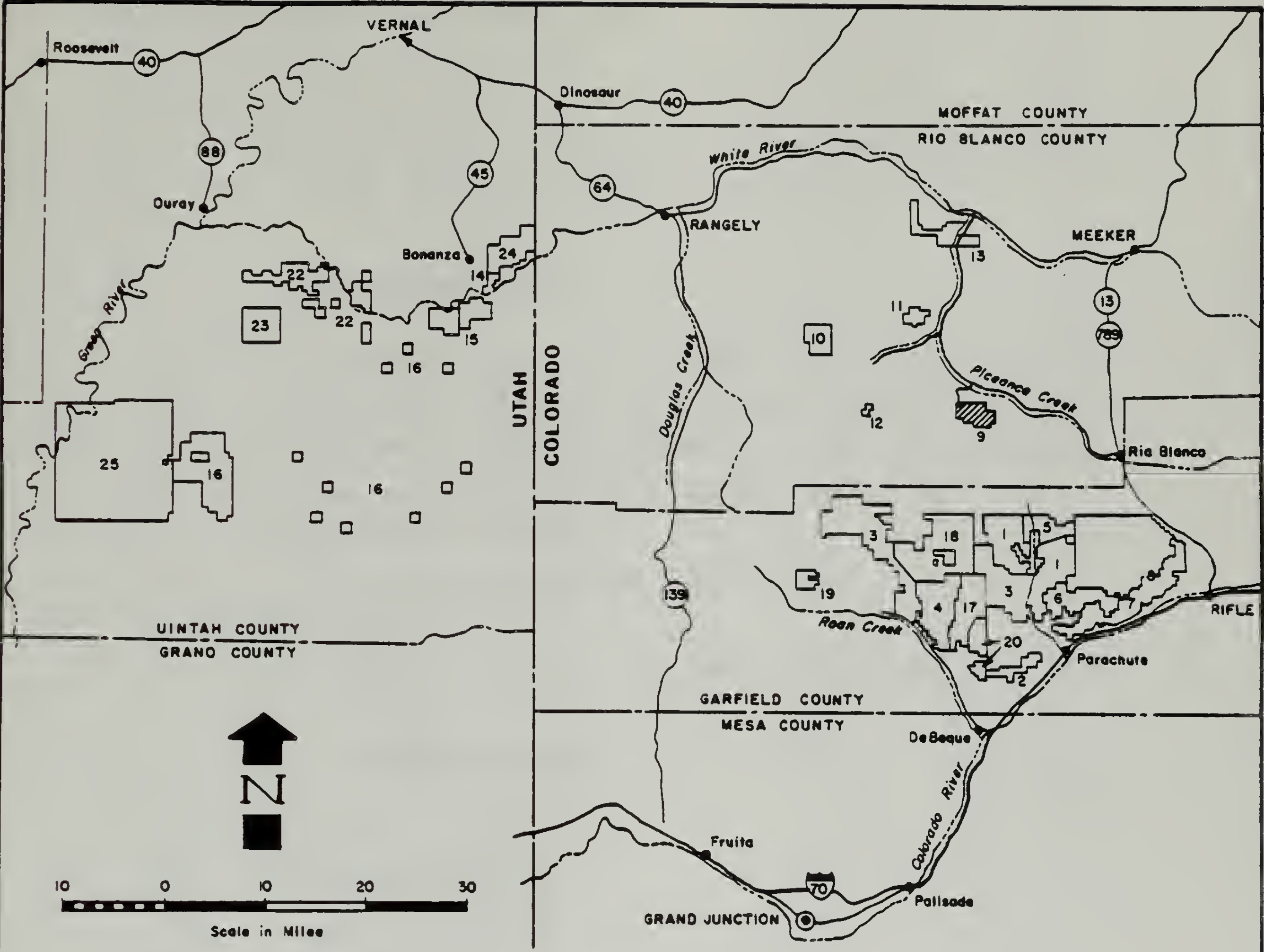
2.0 DESCRIPTION OF PROJECT AREA

2.1 Location

Federal Oil Shale Tract C-b is located in the Piceance Creek structural basin between the Colorado River on the south and the White River on the north. The basin is dominated by a large central plateau which represents more than 75 percent of the basin's land surface. The area represents a sparsely populated portion of the Rio Blanco County in northwestern Colorado. Terrain on the Tract consists primarily of undulating valleys and ridges trending in the northeasterly direction and draining into Piceance Creek. The northern edge of the Tract is approximately one-half mile south of Piceance Creek between Willow Creek and Stewart Gulch. West of the Tract, Piceance Creek flows northwesterly approximately 24 miles to its confluence with the White River. Irrigated-grassland ranching predominates along Piceance Creek. The towns nearest to the Tract are Meeker (45 miles), Rifle (42 miles), Parachute (62 miles) and Rangely (65 miles).

Elevations on the Tract vary from 6,400 feet in the lowest valley bottoms to 7,100 feet on the ridges near the southern edge of the Tract. The climate is semiarid with snow cover occurring variably from October to May. The climate supports sparse vegetation, with sagebrush and pinyon-juniper communities being dominant. Historically, the Tract has been used primarily for cattle grazing and winter range for mule deer. As part of a BLM range improvement program, approximately 45 percent of the Tract (primarily the flat ridgetops) was chained in 1967. The technique was intended to improve range production by removing pinyon-juniper trees, thus permitting growth of grazeable understory.

Location of the Tract relative to other existing and proposed oil shale projects in northwestern Colorado is shown on Figure 2-1.



LEGEND

1 Union

2 Occidental

3 Chevron Clear Creek

4 Pacific Project
- Superior
- Sohio
- Cleveland Cliffs

5 Colony - Exxon, USA

6 Mobil

7 Paraho - Anvil Points

8 Naval Oil Shale Reserve 1 & 3

9 CATHEDRAL BLUFFS (TRACT C-b)
- Occidental
- Tenneco
- P. Kiewit

10 Rio Blanco (TRACT C-a)
- Gulf
- Standard

11 Horse Draw

12 Equity

13 Superior

14 Paraho - Ute

15 White River Tracts (U-a & U-b)

16 Geokinetics

17 Cities Service

18 Getty

19 Shale Energy Corp. of America

20 Shell

22 Tosco Sand Wash

23 Magic Circle

24 Syntana - Utah

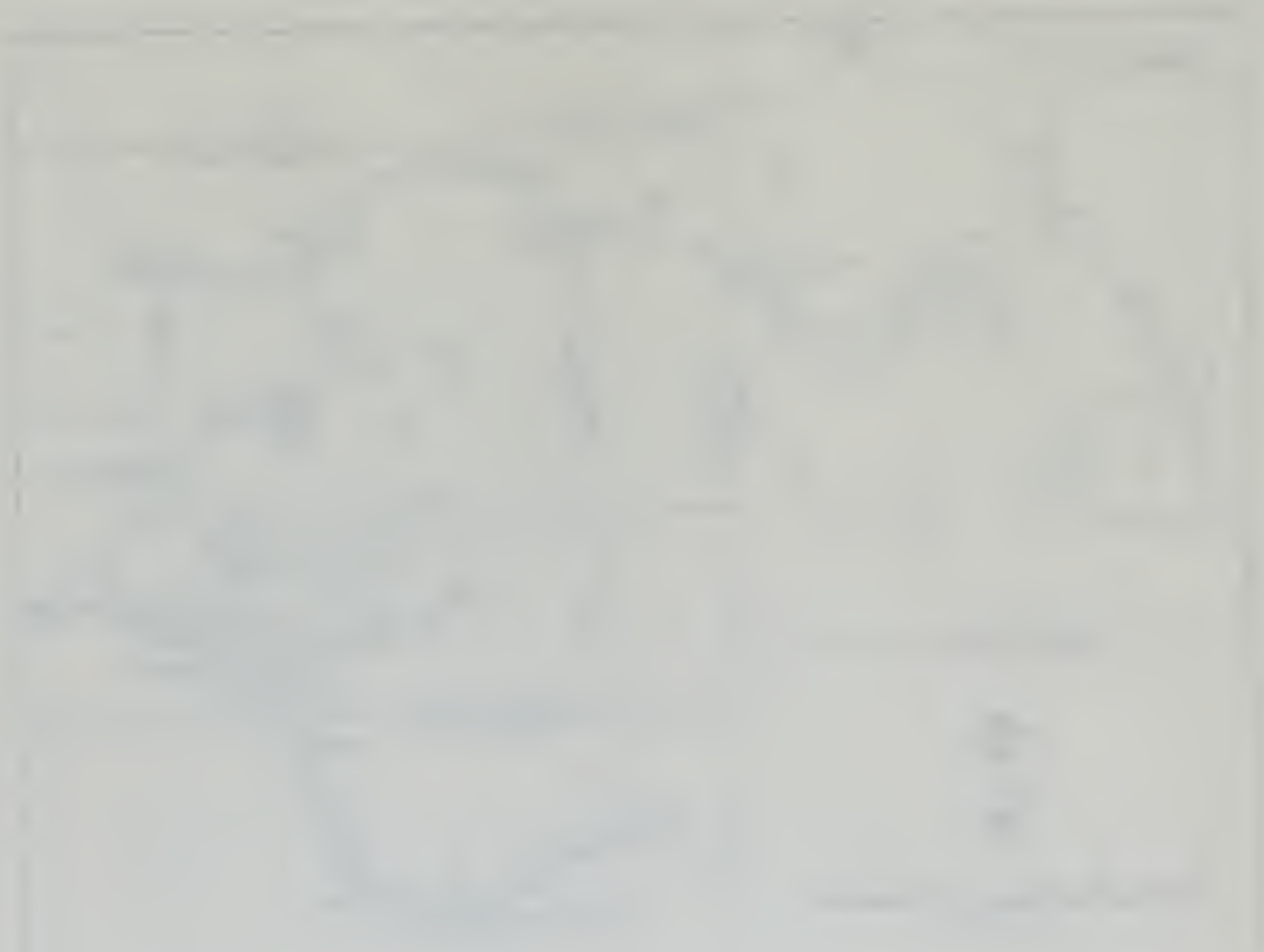
25 Naval Oil Shale Reserve 2

(Item 21 Intentionally Not Noted)

STATUS OF OIL SHALE PROJECTS IN COLORADO AND UTAH
(WYOMING HAS NO OIL SHALE PROJECTS AT PRESENT)

FIGURE 2-1

Source: Bureau of Land Management



2.2 Legal Description of the Leased Land

The Tract, as legally described in U. S. Department of the Interior Oil Shale Lease C-20341, consists of 5,093.9 acres, more or less, which is shown in Figure 2-2 and is located in Rio Blanco County, Colorado, as follows:

T3S, R96W, 6th P.M.

Section 5, W 1/2, SE 1/4, and SW 1/4;
Section 6, lots 6 and 7, E 1/2 SW 1/4, and E 1/2;
Section 7, lots 1, 2, 3, and 4, E 1/2 W 1/2, and E 1/2;
Section 8, W 1/2, NE 1/4, NW 1/4, and S 1/2;
Section 9, SW 1/4;
Section 16, NW 1/4, and W 1/2 SW 1/4;
Section 17;
Section 18, lots 1, 2, 3, and 4, E 1/2 W 1/2, and E 1/2;

T3S, R97W, 6th P.M.

Section 1, S 1/2;
Section 2, SE 1/4;
Section 11, E 1/2;
Section 12;
Section 13, N 1/2;
Section 14, N 1/2 NE 1/4.

2.3 Leasehold Status

The Lease requires that a Detailed Development Plan (DDP) be developed prior to its third anniversary date. Such a plan was developed for underground mining and surface retorting in 1976. A plan modification to incorporate modified in situ retorting was prepared with options and alternatives for surface retorting and power generation in 1977. The scope of the DDP was

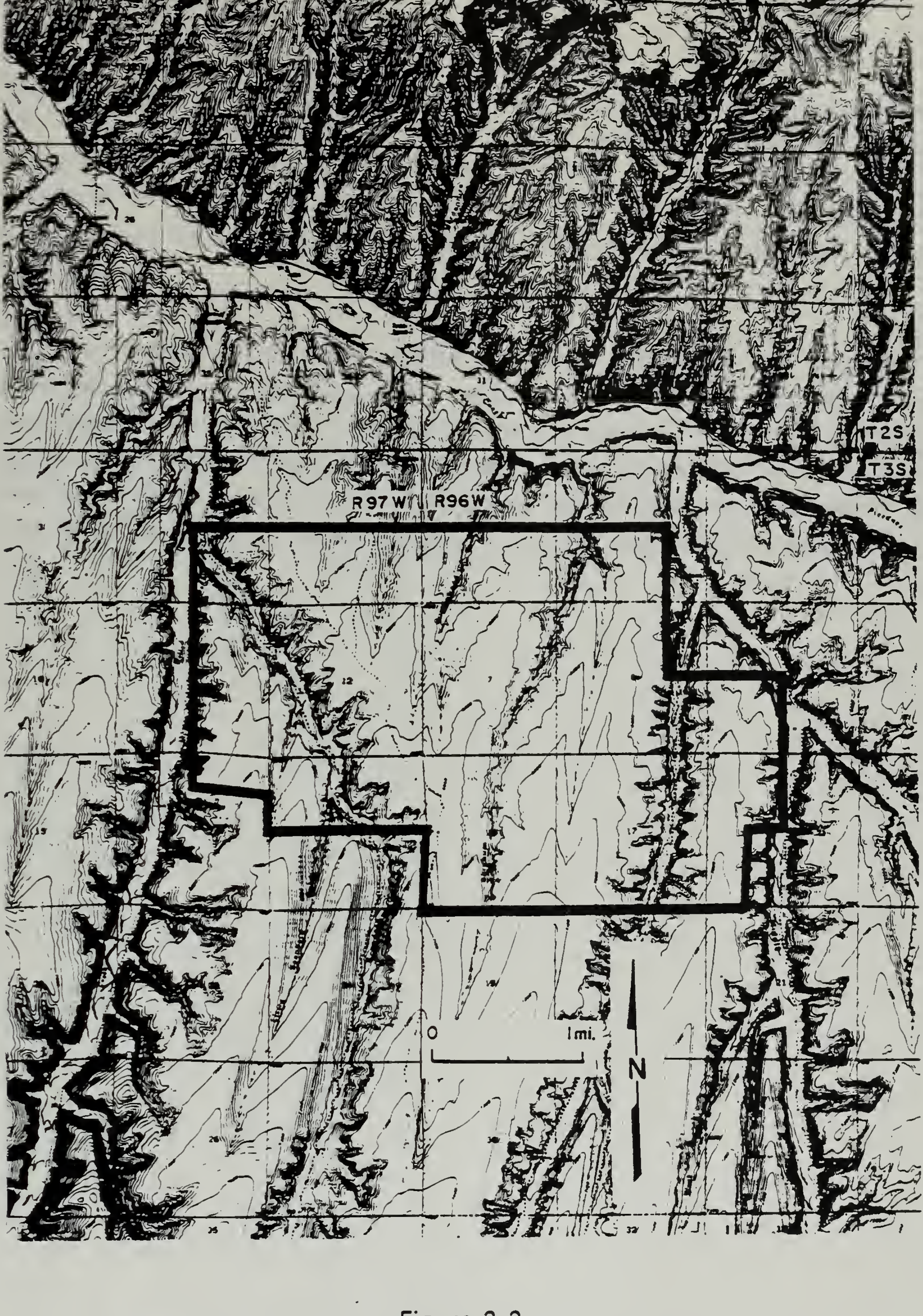


Figure 2-2
Location of tract C-b according to range, township and section

further amended in 1982 under an Interim Development Program and judged by the Oil Shale Project Manager to be entirely consistent with Due Diligence Requirements of the Lease. A Revised Detailed Development Plan Draft was submitted to the Oil Shale Project Office (OSPO) on February 10, 1984. This Annual Report is a requirement of the Lease and summarizes operations conducted under the DDP.

Furthermore, the Lease stipulates that operations be conducted in compliance with all Federal, State and local regulations and laws. Lease Environmental Stipulations are set forth to protect the environment; the current environmental monitoring program called Interim Monitoring is consistent with these stipulations and forms part of the Detailed Development Plan. This Annual Report also summarizes results of the environmental program.

3.0 PROJECT STATUS, SCHEDULE AND COSTS

3.1 Project Status

The Project's status is more accurately reflected in CB's draft Revised Detailed Development Plan (RDDP) filed with the OSPO on February 10, 1984. In particular, the schedules and production targets referred to herein should be considered subject to and controlled by those that now appear in that document or will appear in it when it is finally approved.

In January of 1983, CB submitted a proposal for financial assistance to the U.S. Synthetic Fuels Corporation (SFC) in response to their Third Solicitation. On July 28, 1983, the SFC announced it had signed a Letter of Intent to provide up to $2.19 billion in loan and price guarantees to the Project. CB now anticipates reaching a final agreement with the SFC in mid-1984. Nothing in the SFC agreement is intended to be in conflict with or to abrogate the directives of the Oil Shale Project office.

The CB Project is intended to produce approximately 14,100 barrels per calendar day (BPCD) of a commercial crude oil substitute. The Project includes mining, a commercial aboveground retort (AGR) using Union Oil Company's Unishale B process, four continuously burning modified in situ (MIS) retorts using the MIS technology developed by Occidental Oil Shale, Inc., an upgrading facility for treatment of raw shale oil, an approximate 46 mile pipeline and terminal and incidental facilities. Oil shale feedstock to the aboveground retort will be provided primarily by ore from a commercial room and pillar mine and will be supplemented by ore obtained from preparation of the MIS retorts. The crude shale oil will be upgraded on the Tract (using Union Oil Company's upgrading technology) to produce a crude oil substitute. The upgraded synthetic fuel will be shipped via pipeline to a distribution terminal in Rangely, Colorado. The Project is expected to produce approximately 11,000 BPCD of raw shale oil from the aboveground retort and approximately 2,300 BPCD of raw shale oil from the four MIS retorts. The oil upgrading facility will yield approximately 14,100 BPCD of a commercial crude oil substitute. The expected production life of the Project is not less than thirty years, during which time the Project is expected to produce approximately 150 million barrels of upgraded synthetic fuel. First oil production is projected in 1987, and full commercial production is expected to be reached in 1989.

At Occidental's Logan Wash Facility, the processing of two commercial sized modified in situ retorts, similar in design to those planned for the CB Project, was terminated in mid-November 1982 and water quenching, a sequel operation, was initiated. The objective of the water quenching step in the MIS process is to 1) remove residual heat from the spent shale that, if unremoved, may tend to degrade the strength of mine support pillars, and 2) improve the quality of process waters by the distillation process within the spent retorts. Water was injected into the retorts during 1983 at a rate comparable to that anticipated in commercial operations. Results indicated that the objectives were realized. Quenching has been terminated, the retorts have been cooled and are now inactive and sealed.

Status of the Project with regard to environmental protection and control and permitting is summarized in Section 7.0.

3.2 Schedule

3.2.1 "Milestone" Schedule

The OSPO approved "Milestone" or Project Guide Schedule (as approved in 1978) is given on Figure 3-1. This schedule has been modified by subsequent OSPO action as follows:

- An interim operation plan was approved on September 1, 1981 which allows the V/E Shaft to fill with water under upset conditions (including mine water from all three shafts) until it is necessary to draw down the water for mine development.

- An Interim Monitoring Program was approved on March 17, 1982 and revised on July 22, 1982 to reflect the reduced level of activity on Tract through March 1983. The Interim Monitoring Program has recently been extended through 1984.

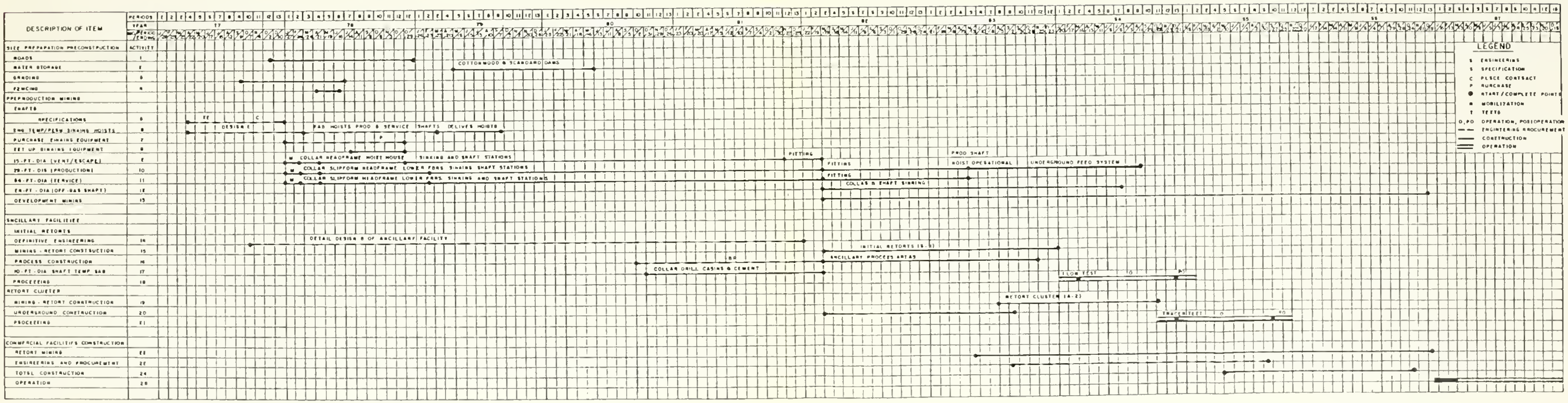


FIGURE 3-1
OVERALL PROJECT GUIDE SCHEDULE

- An Interim Development Program and Schedule was approved on July 22, 1982 to reflect the reduced level of activity commensurate with the December, 1981 announcement by CB management that the entire project was being reassessed due to oil prices, interest rates and project costs. This schedule which was included in previous Annual Reports is given on Figure 3-2, with revisions.

- As discussed elsewhere, design optimization proceeded to the point which allowed submittal of proposals to the Synthetic Fuels Corporation for financial participation in the Project and more recently submittal of a Revised Detailed Development Plan draft (RDDP) to the OSPO. The RDDP-basis schedule is given on Figure 3-3 for information. It is similar to and consistent with the OSPO approved Interim Development Schedule of Figure 3-2.

3.2.2 Schedule vs. Actual Activities in 1983

Figure 3-4 shows site preparation and construction activities from 1981-1983 compared with the previously developed milestone schedule for this time span. On-Tract activities in 1983 were significantly reduced; there was no on-site construction in 1983. The major contractors on Tract are noted in Table 3-1.

3.3 Costs

Financial information for 1983 is presented in Table 3-2 for the following categories: field construction, engineering, operating costs, environmental, other programs, general and administrative staff. Total expenditures for the year were $14,477,000.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

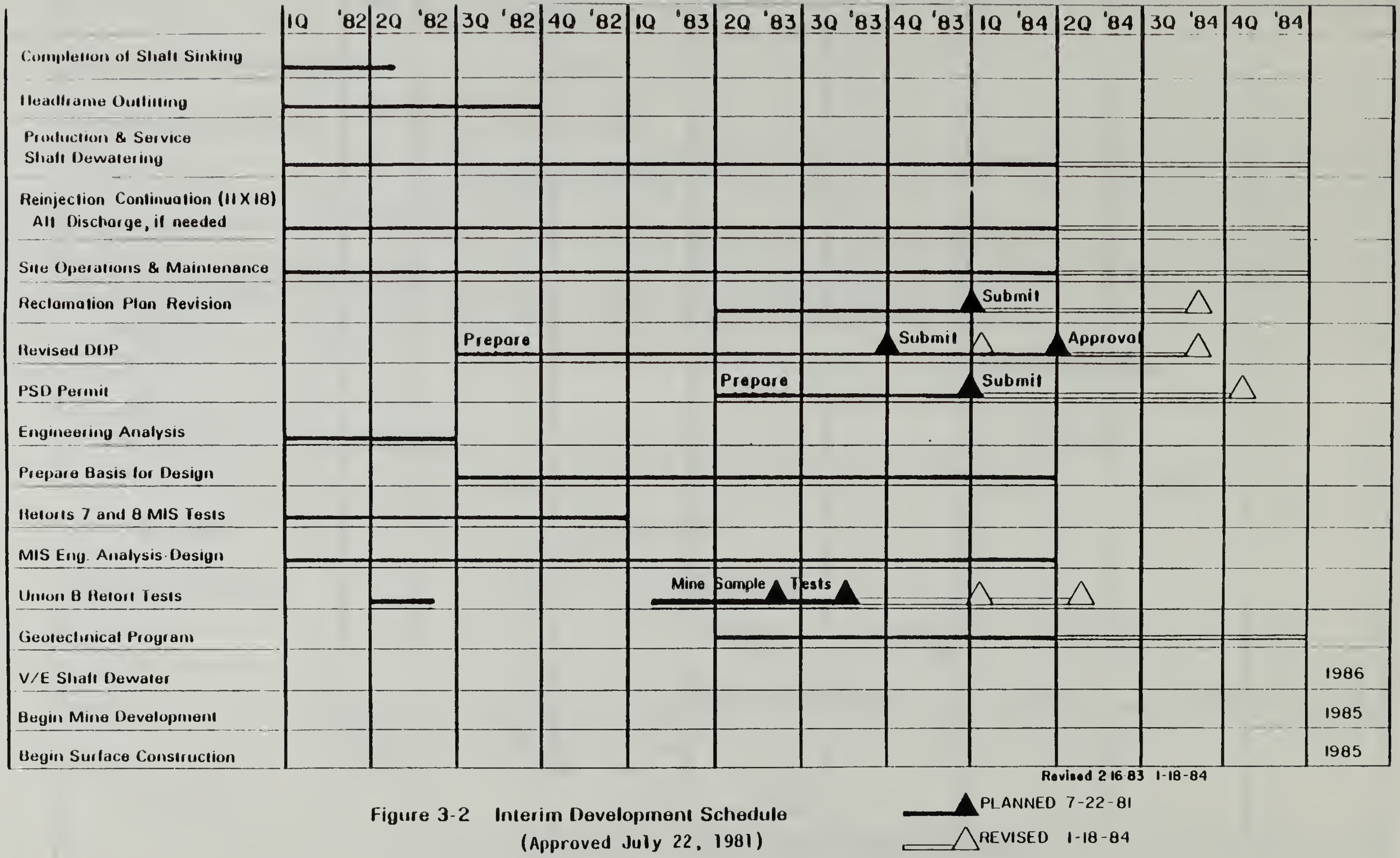


Figure 3-2 Interim Development Schedule
(Approved July 22, 1981)

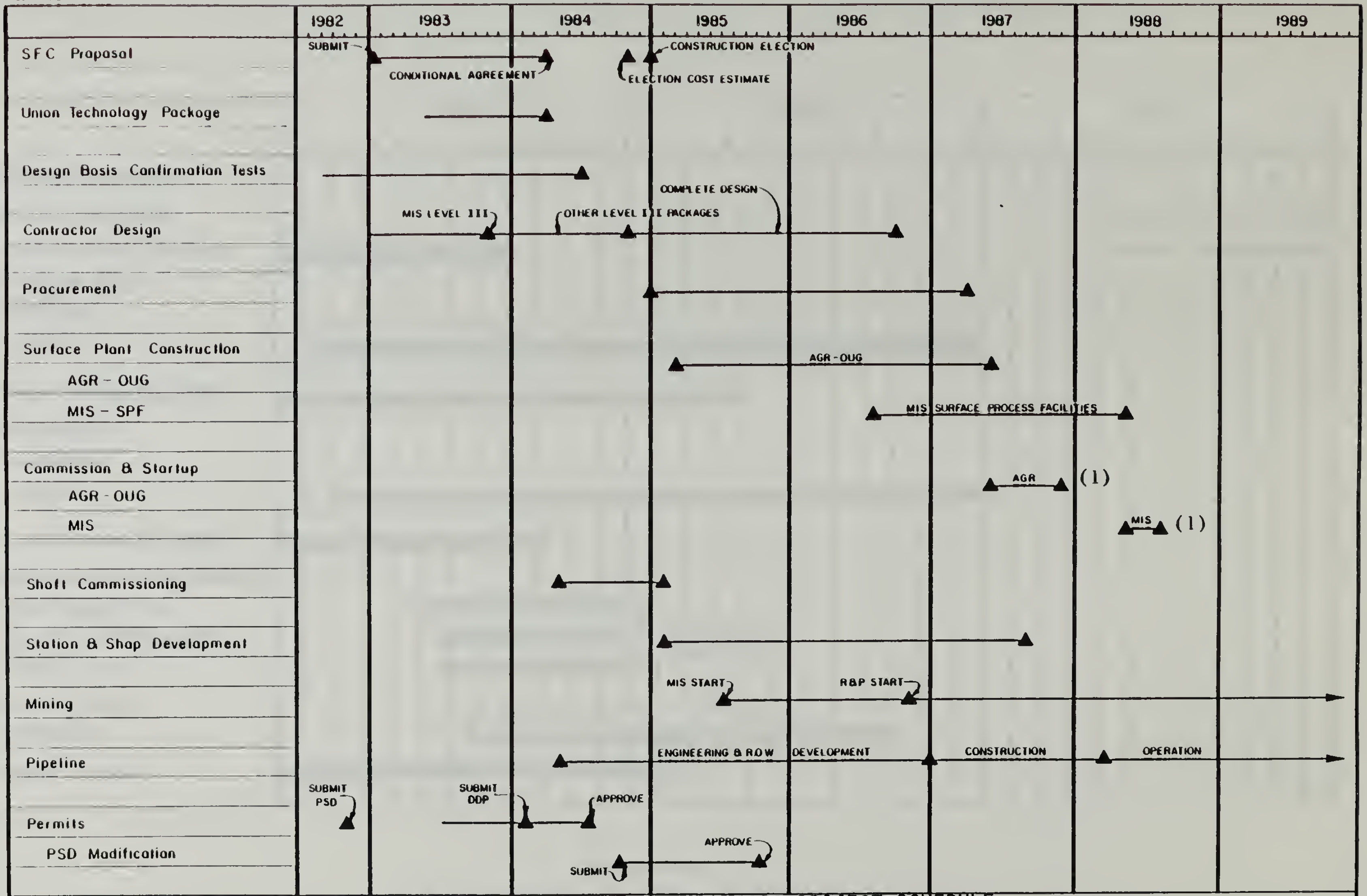


FIGURE 3-3 RDDP BASIS PROJECT SCHEDULE

(1) Start of Commercial Operations 1989

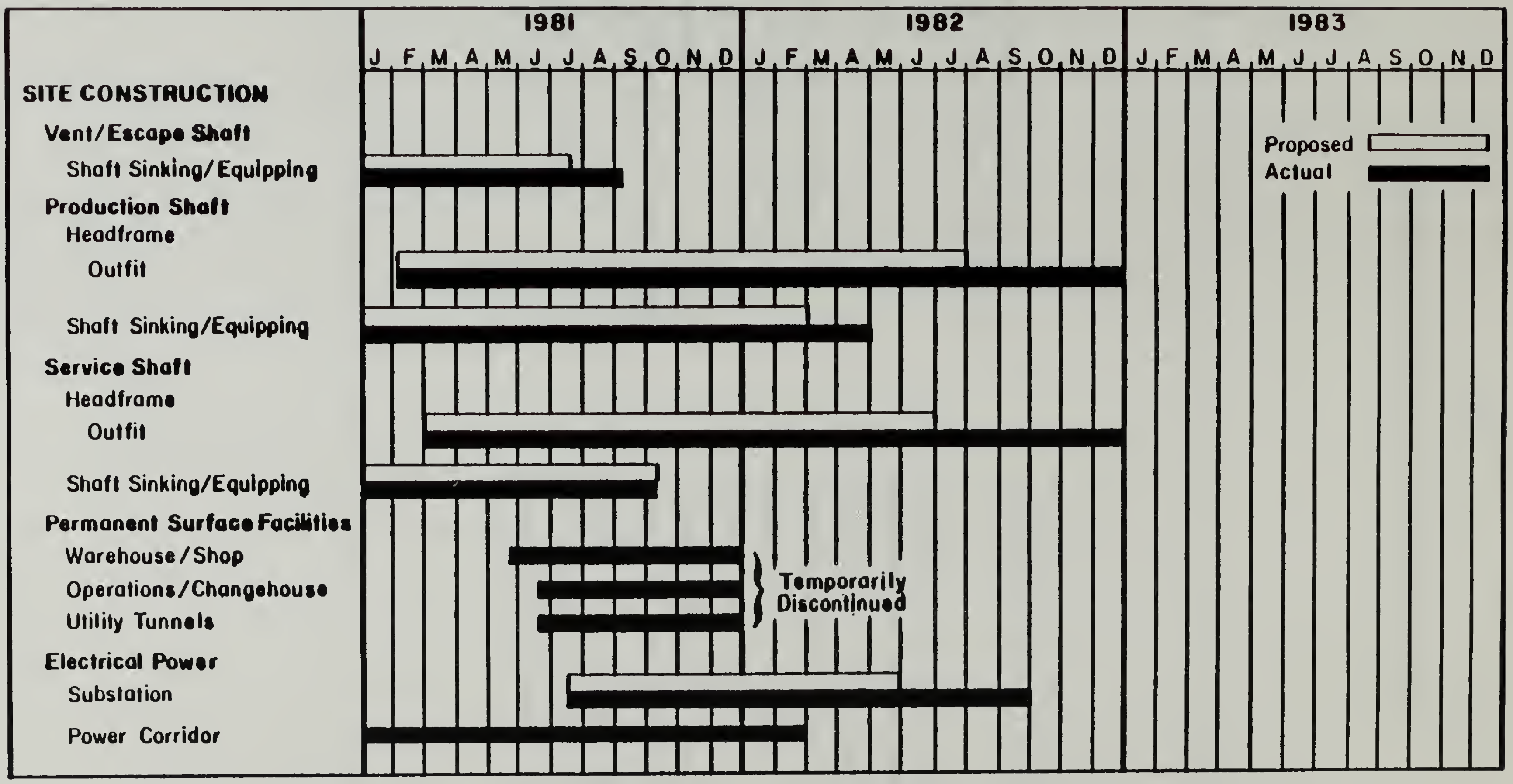


Figure 3-4
C.B. Construction Activities in 1981-1983

TABLE 3-1

1983 Major Contractors and Responsibilities

Bechtel	Project definition studies
Canadian General Electric	Supervising hoist installation
Colorado River Water Conservation District	Surface-stream monitoring program
Colo-Macco	Operation and maintenance labor
Fluor	Project definition studies
Geothermal Surveys, Inc.	Hydrologic monitoring
Himes Drilling Co., Inc.	Geotechnical Drilling
Mariah Associates	Aquatic sampling
Stearns-Roger	Project definition studies
Stoecker-Keammerer & Associates	Vegetation and wildlife monitoring
Union Oil	Process pilot plant studies
U.S. Bureau of Mines	Dust explosivity studies
Woodward-Clyde	Spent shale disposal studies

TABLE 3-2

1983 CB EXPENDITURES
(Thousands of $)

Field Construction		
Shaft Sinking	$ (489)[1]	
Headframe Construction	650	
Power Generation Costs	(28)[2]	
Other Construction	450	
		$ 538
Engineering Costs		5,469
Operating Costs		
Tract Operations and Maintenance		720
Environmental		
Air Quality and Hydrology	53	
Water Resource Development	52	
Biology and Reclamation	42	
Permits	28	
Systems Analysis and Reporting	7	
Environmental DDP	74	
		256
Other Programs		
Housing	(50)[3]	
Busing	6	
Insurance, Bonding and Property Taxes	290	
Other	148	
		394
General and Administrative Staff Costs		
Environmental Staff	669	
All Other Staff	4,469	
Employment Expenses	76	
Legal Expense	272	
Office Expense	637	
Other Expense	977	
		7,100
TOTAL PROJECT		$14,477

1 Gilbert workman's compensation adjustment from previously estimated to actual expenses.
2 Over accrual of final 1982 billing
3 Receipts exceeded expenses.

4.0 DEVELOPMENT ACTIVITIES

4.1 On-Tract Facilities Description

4.1.1 General Arrangement

Construction activities in 1983 consisted primarily of the commissioning of the production, service and auxiliary hoists, post construction cleanup, and facility maintenance. No new buildings or any other structures or facilities have been constructed during 1983.

Existing on-Tract facilities are shown in the following figures:

Figure 4-1: C-b Tract Topographic Map (Jacket Map)
Figure 4-2: Mine Support Area
Figure 4-3: V/E Shaft and Ponds A & B*
Figure 4-4: Guard Building and Heliport
Figure 4-5: Pond C Area*
Figure 4-6: Explosives Storage Area

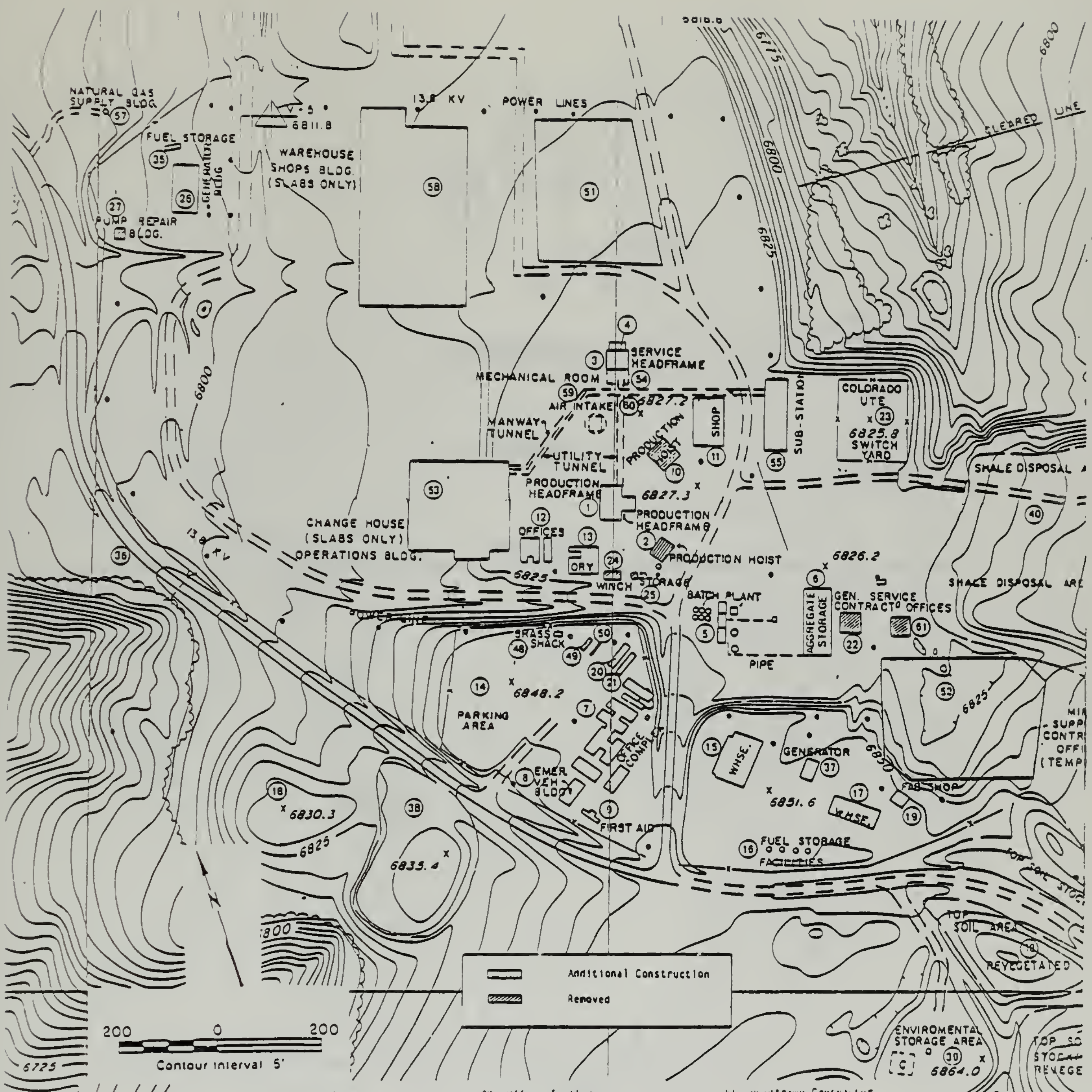
* See also Figure 4-7 for additional details on the surface water management system.

Table 4-1 is the key to the numbers shown on Figures 4-1 through 4-6.

When these figures are compared with the corresponding figures in the 1982 Annual Report, it becomes apparent that no new construction has been started during 1983. Existing site facilities are being maintained status-quo until construction activities are resumed. Those buildings on Figure 4-2 indicated by cross-hatching as being removed were previously removed in 1982.

4.1.2 Production Shaft Headframe

Canadian General Electric (CGE) completed the electrical hook-up of the two 9500 hp production hoists. The ropes for skip hoist A, which were installed during 1982, were then lowered into their respective positions on the hoist drum. The drum was grooved and the tailropes were trimmed to the proper length to ensure proper travel of the conveyances. The electromagnetic sensing devices which control the hoist speed during automatic operation were installed. Dorr-Oliver then balanced the skips by adding weight to the #2 skip.



1. Production Headframe
2. Production Hoist
3. Service Headframe
4. Control Room
5. Cement Batch Plant
6. Cement Batch Plant Aggregate Storage
7. Office Complex
8. Emergency Vehicle Building
9. First Aid Trailer
10. Production Hoist
11. Shop
12. Offices
13. Dry
14. Parking Area
15. Main Warehouse
16. Fuel Storage Facilities
17. Warehouse
18. Topsoil Storage Area
19. Fabrication Shop
20. Office Trailer
21. Office Trailer
22. General Service Contract Offices
23. Colorado Ute Switchyard
24. Winch
25. Storage Building
26. Generator Building
27. Pump Repair Building
35. Fuel Storage
36. Paved Main Access Road
37. Generator
38. Storage Yard
39. Environmental Storage Building
40. Shale Disposal Area
48. Grass Shack
49. Hydrology/Air Laboratory
50. Soils Lab
51. Headframe Contractor Offices
52. Mine Support Contractors Offices
53. Changehouse/Operations Building (slabs only)
54. Mechanical Room-Service Shaft
55. Mine Support Area Substation
57. Natural Gas Supply Building
58. Warehouse/Maintenance Shop (slabs only)
59. Manway Tunnel from Changehouse to Service Headframe
60. Utility Tunnels from Substation to Service/Production Headframes and Changehouse
61. General Service Contractors Office

Figure 4-2

Topographic map showing facilities in the Mine Support Area

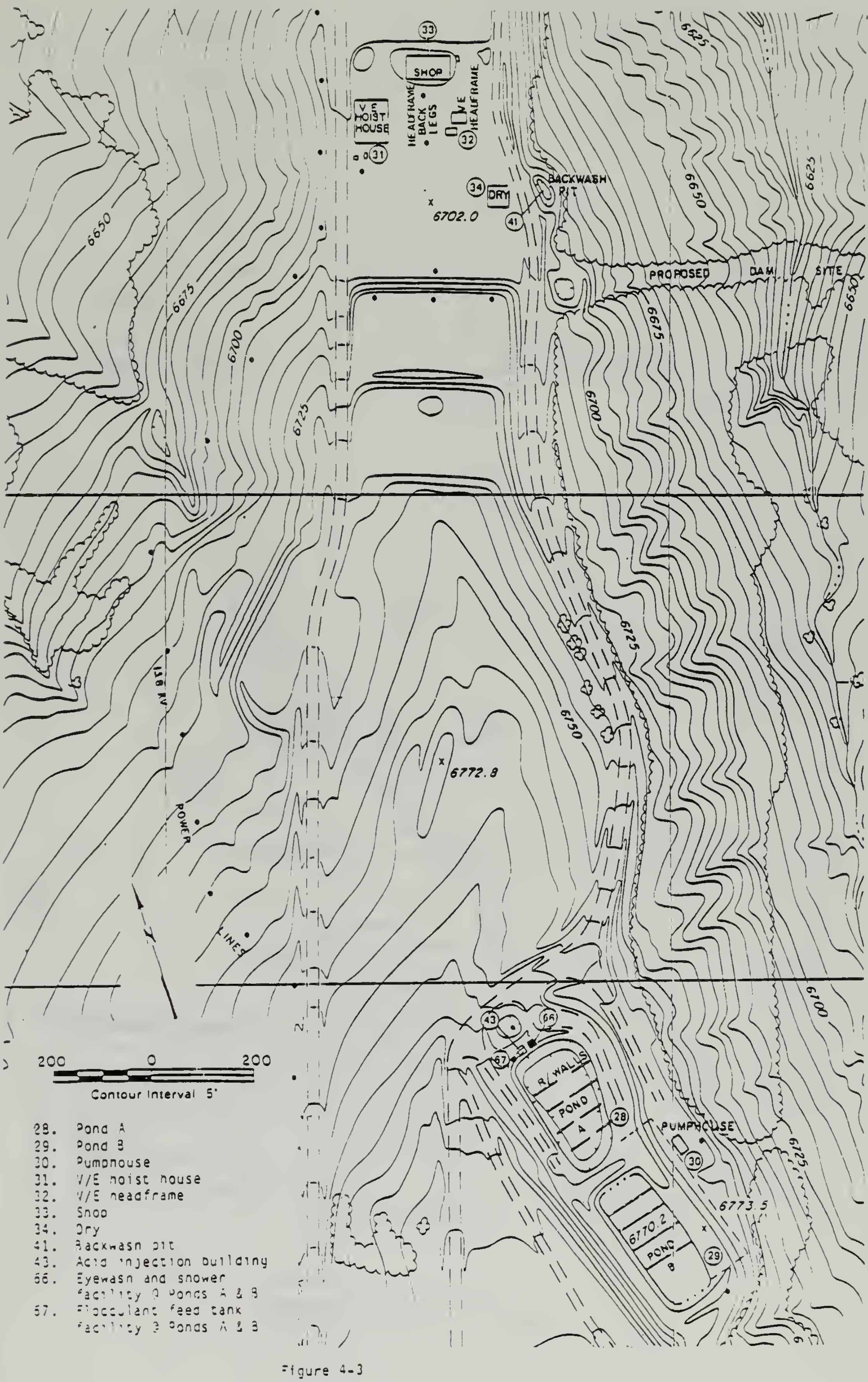


Figure 4-3

Topographic map showing facilities near the V/E Shaft and Ponds A and B

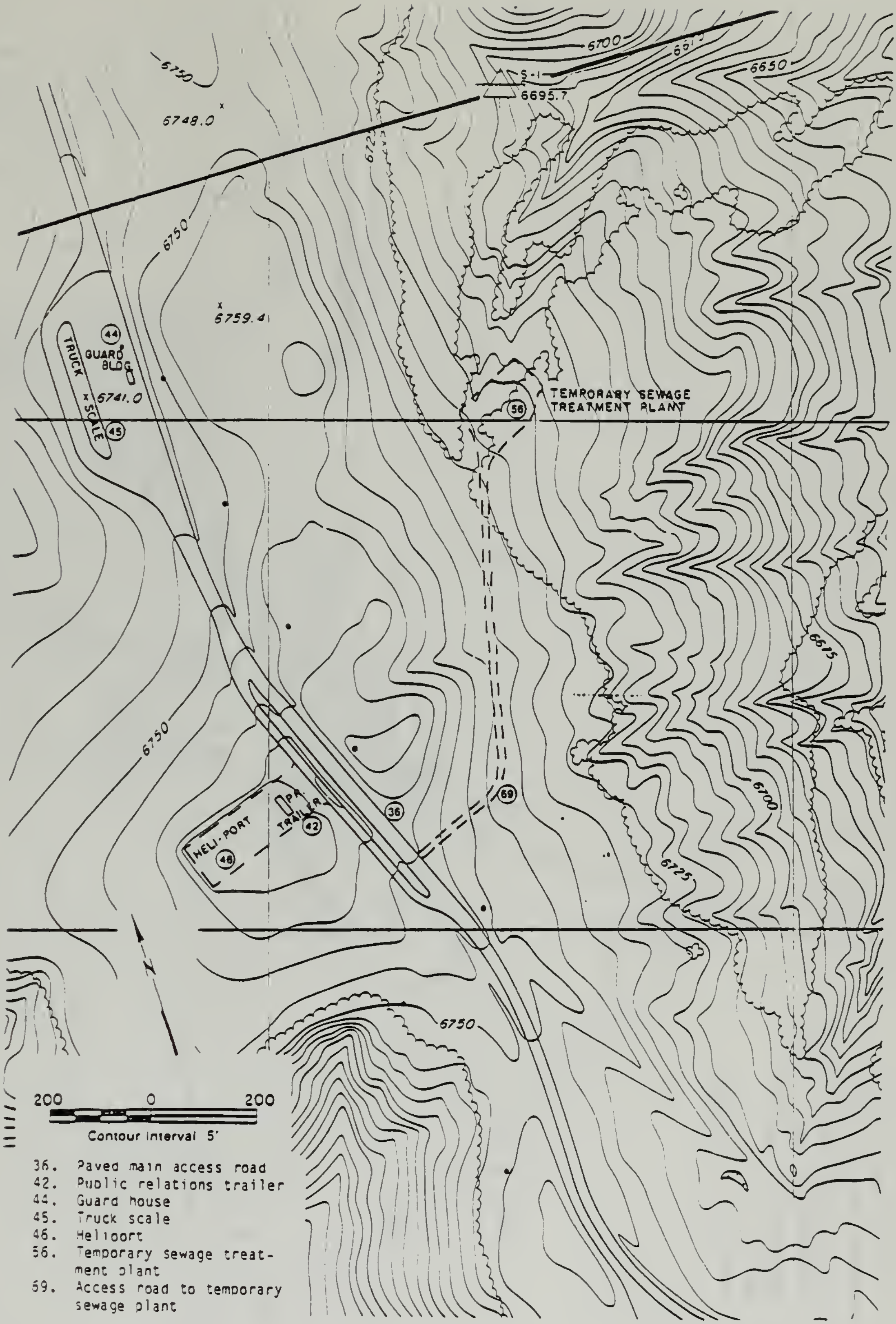


Figure 4-4

Topographic map showing facilities near the Guard Building and Heliport

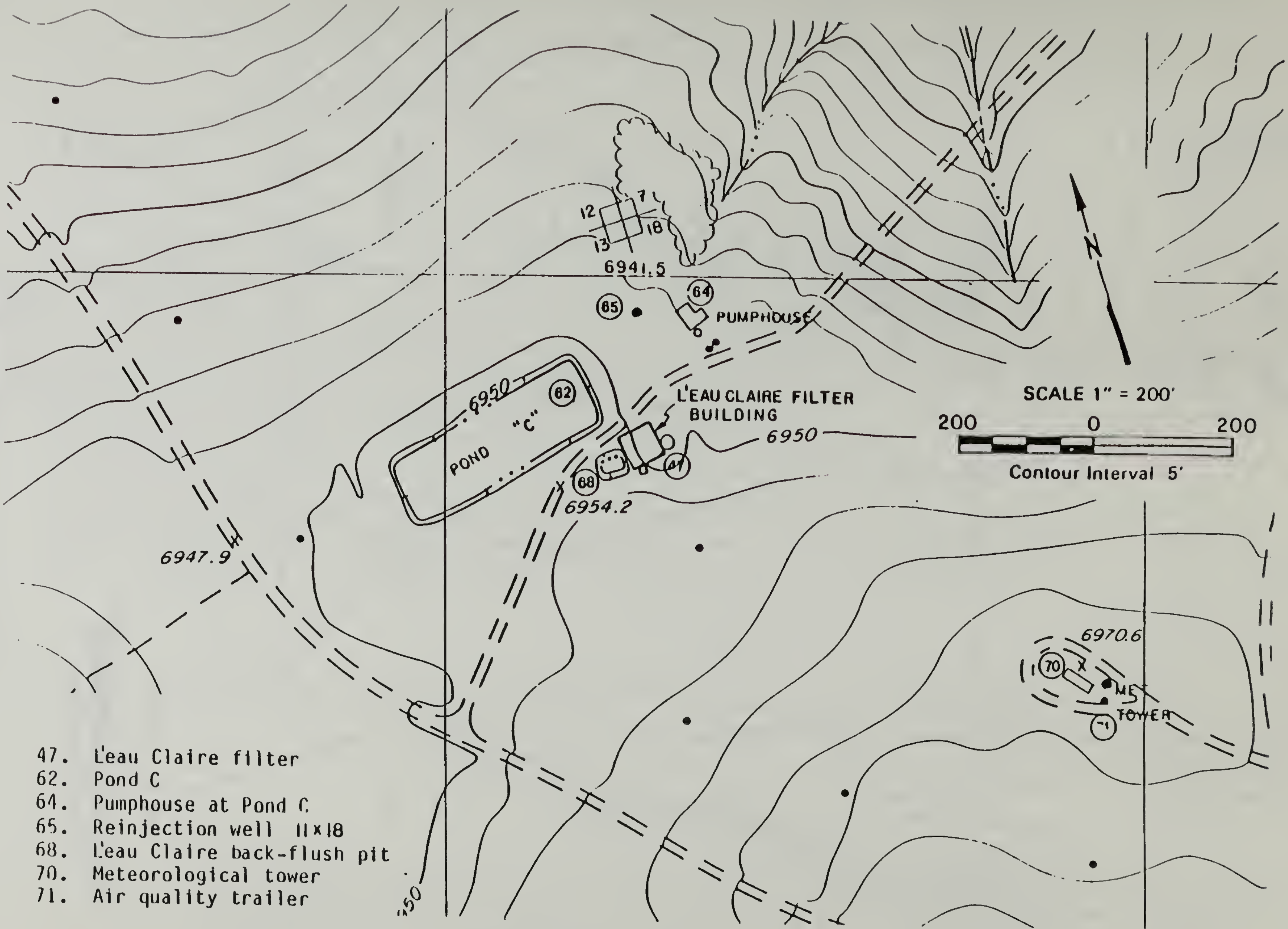


Figure 4-5

Topographic map showing facilities near Pond C

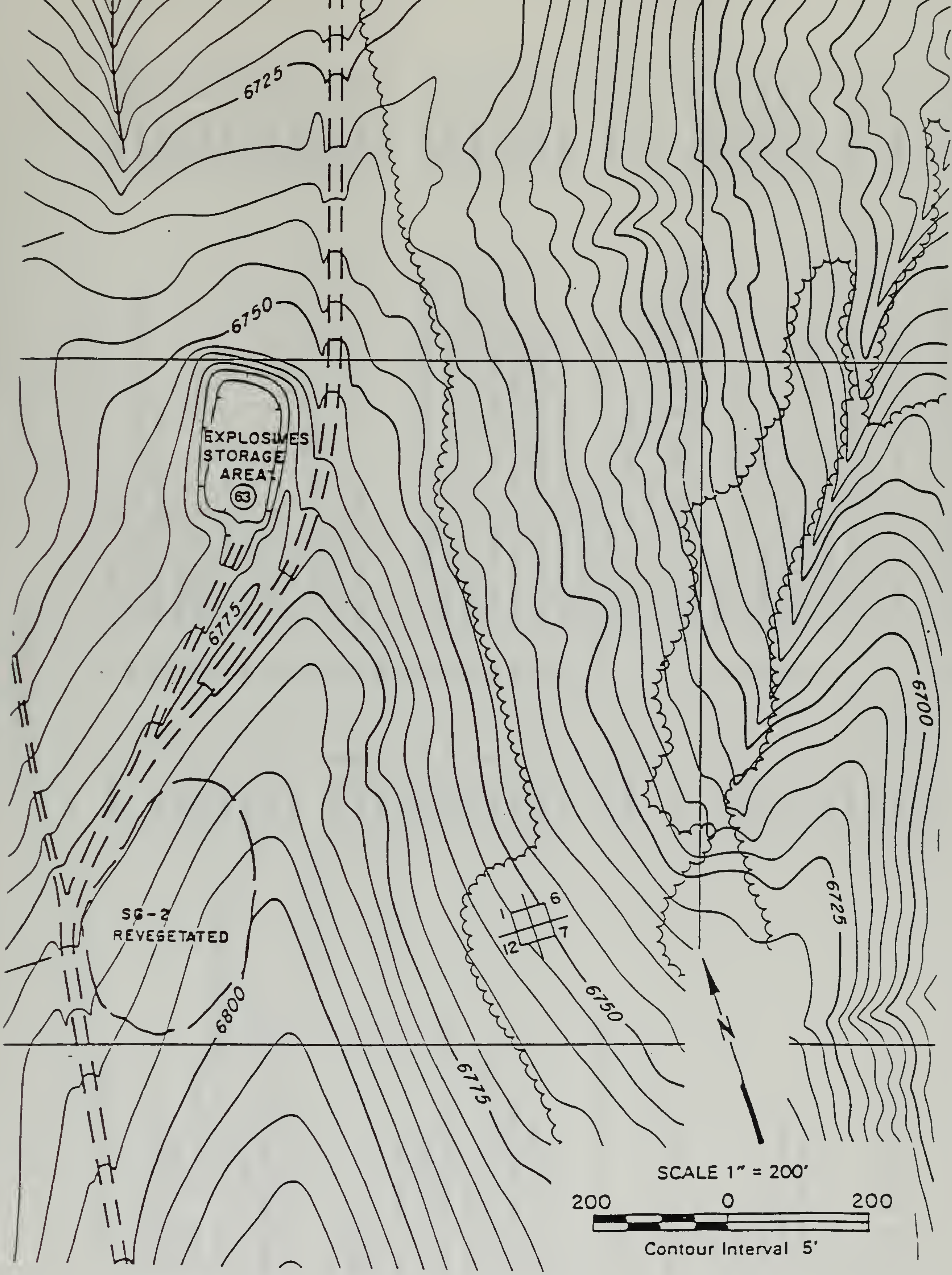


Figure 4-6

Topographic map showing facilities near the Explosives Storage area

TABLE 4-1

Facilities List

No.	Facility	Location	No.	Facility	Location
1.	Production Headframe	Figure 4-1	38.	Storage Yard	Figure 4-2
2.	*		39.	Environmental Storage Building	Figure 4-2
3.	Service Headframe	Figure 4-2	40.	Shale Disposal Area	Figure 4-2
4.	Control Room	Figure 4-2	41.	Backwash Pit	Figure 4-3
5.	Cement Batch Plant	Figure 4-2	42.	Public Relations Trailer	Figure 4-4
6.	Cement Batch Plant Aggregate Storage	Figure 4-2	43.	Acid Injection Building	Figure 4-3
7.	Office Complex	Figure 4-2	44.	Guard House	Figure 4-4
8.	Emergency Vehicle Building	Figure 4-2	45.	Truck Scale	Figure 4-4
9.	First Aid Trailer	Figure 4-2	46.	Heliport	Figure 4-4
10.	*		47.	L'eau Claire Filter	Figure 4-5
11.	Shop	Figure 4-2	48.	Brass Shack	Figure 4-2
12.	Offices	Figure 4-2	49.	Hydro/Air Lab	Figure 4-2
13.	Dry	Figure 4-2	50.	Soils Lab	Figure 4-2
14.	Parking Area	Figure 4-2	51.	*	
15.	Main Warehouse	Figure 4-2	52.	Mine Support Contractors Offices	Figure 4-2
16.	Fuel Storage Facilities	Figure 4-2	53.	Changehouse/Operations Bldg. Slab	Figure 4-2
17.	Warehouse	Figure 4-2	54.	Mechanical Room - Service Shaft	Figure 4-2
18.	Topsoil Storage Area	Figure 4-2	55.	Mine Support Area Substation	Figure 4-2
19.	Fabrication Shop	Figure 4-2	56.	Temporary Sewage Treatment Plant	Figure 4-4
20.	Office Trailer	Figure 4-2	57.	Natural Gas Supply Building	Figure 4-2
21.	Office Trailer	Figure 4-2	58.	Warehouse/Maintenance Shop Building Slab	Figure 4-2
22.	*				
23.	Colorado Ute Switchyard	Figure 4-2	59.	Manway Tunnel from Changehouse to Service Headframe	Figure 4-2
24.	Winch	Figure 4-2			
25.	*		60.	Utility Tunnels from Substation to S/P Headframes & Changhouse	Figure 4-2
26.	Generator Building	Figure 4-2			
27.	*		61.	General Service Contractors Office	Figure 4-2
28.	Pond A	Figure 4-3	62.	Pond C	Figure 4-5
29.	Pond B	Figure 4-3	63.	Explosives Storage Area	Figure 4-6
30.	Pumphouse	Figure 4-3	64.	Pumphouse at Pond C	Figure 4-5
31.	V/E Hoist House	Figure 4-3	65.	Reinjection Well	Figure 4-5
32.	V/E Headframe	Figure 4-3	66.	Eyewash and Shower Facility at Ponds A & B	Figure 4-3
33.	Shop	Figure 4-3			
34.	Dry	Figure 4-3	67.	Flocculant Feed Tank Facility at Ponds A & B	Figure 4-3
35.	Fuel Storage	Figure 4-2			
36.	Paved Main Access Road	Figure 4-2, & Figure 4-4	68.	L'eau Claire Back-Flush Pit	Figure 4-5
37.	Generator	Figure 4-2	69.	Access Road to Temporary Sewage Plant	Figure 4-4
			70.	Meteorological Tower	Figure 4-5
			71.	Air Quality Trailer (Station 023)	Figure 4-5

* Facilities since removed; see Figure 4-2

Other electrical interlocks and controls remain to be installed and activated prior to the completion of the hoisting system, but skip hoist A is now fully operational. Skip hoist B also became operational, but was not roped up.

Post construction cleanup was also a major task. The upper hoist floor was cleaned and painted to help control dust. All floors in the headframe will eventually be painted. Temporary heaters have been installed and will continue to be used until construction is resumed and the permanent heating system completed.

4.1.3 Service Shaft Headframe

CGE completed the hook-up and commissioning of the three hoists in the service shaft headframe during 1983. Auxiliary hoist #2 was completed first, followed by the main hoist and auxiliary hoist #1. Before tests were completed on the main cage, a deficiency was discovered in the cage crosshead. The cage is currently fully operational, but has a reduced capacity until corrections are made. A complete survey of the fixed guides and a check of cage plumbness was performed. Maintenance was performed during the year to keep all hoisting equipment in first-rate condition, such as changing ropes on both auxiliary hoists.

Post construction cleanup of the service shaft headframe was completed during the year. All three floors in the headframe have been painted. Temporary heaters have also been installed and are in use until the permanent system is completed when construction is resumed.

4.1.4 Ventilation/Escape Hoist and Headframe

No change in 1983.

4.1.5 Electric Power and Switching Facilities

No change in 1983.

4.1.6 Water Wells

No change in 1983.

4.1.7 Office, Warehouse, and Shop Facilities

No change in 1983.

4.1.8 Concrete Batch Plant

No change in 1983.

4.1.9 Explosives Storage and Use

1750 nonelectric caps, 1100 pounds of powder and 500 pounds of ammonium nitrate fuel oil (ANFO) explosives were used during 1983. These explosives were used for the mining of the bulk sample described in Section 4.4.4. No explosives are currently stored in the explosives magazine (see Figure 4-6).

4.1.10 Water Treatment Facilities

The surface water facility (see Figures 4-3, 4-5 and 4-7) is designed to handle water produced in dewatering the mine for project development use. This is accomplished by discharge to surface tributaries of Piceance Creek from the lower ponds (A & B) or by sprinkler irrigation or to a subsurface reinjection system from upper pond C to inject any surplus water or water that may in the future be required for augmentation of depletions of senior water right holders supplies.

The pH is monitored at the overflow between ponds A & B by a continuous pH meter. The pH of the mine water is adjusted when necessary to maintain a range from 6 to 9 at ponds A & B by the addition of sulfuric acid. A storage tank and associated piping deliver acid as needed to lower the pH of the water at each pond. Grab samples are taken at other points in the ponds to assure that proper control of the pH is being maintained in the range from 6 to 9. In 1983 no addition of acid was required.

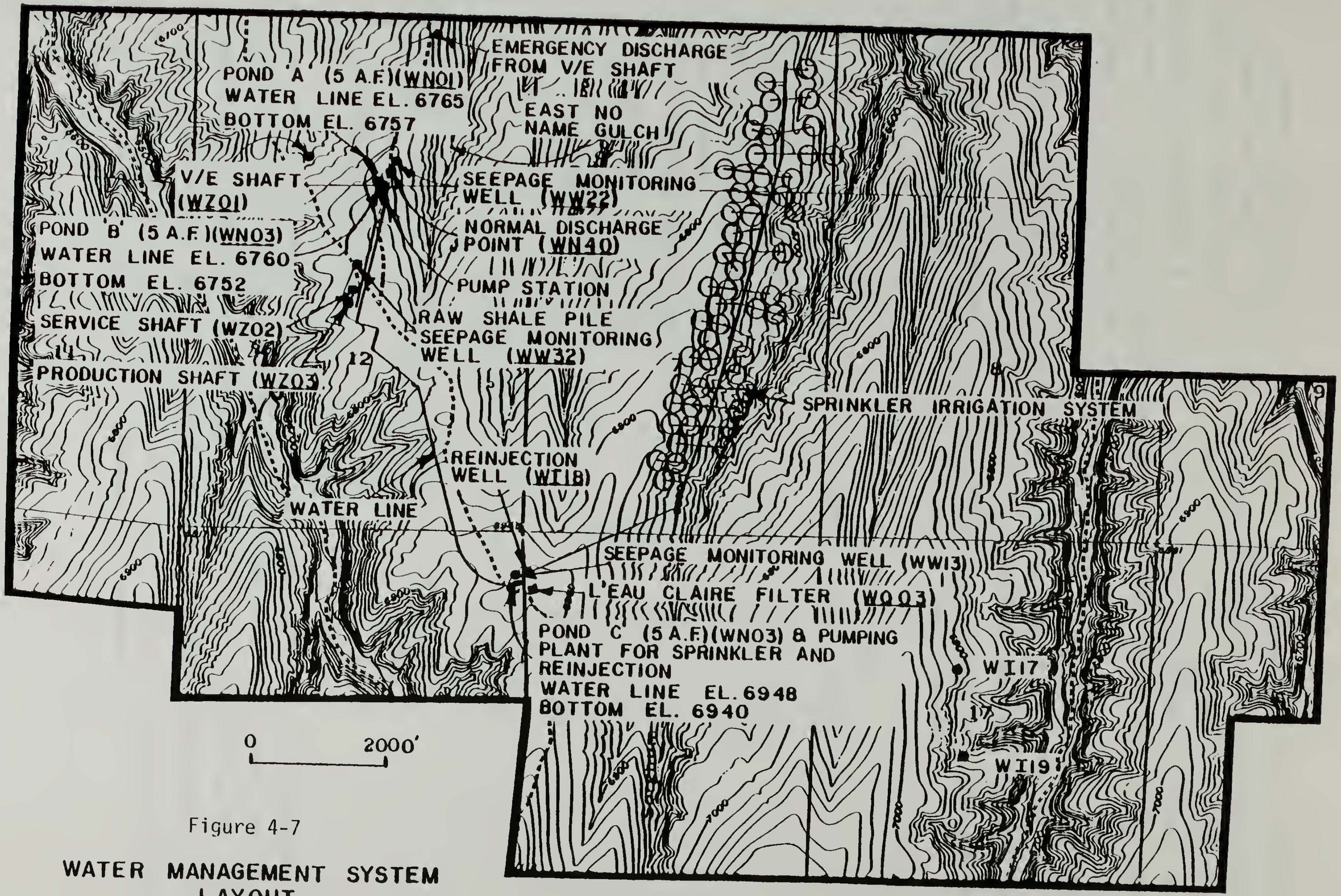


Figure 4-7

WATER MANAGEMENT SYSTEM
LAYOUT

Suspended solids are settled out in ponds A & B when necessary with addition of polymer flocculents. Nalco #8852 or Magnifloc #573-C have been used with great success. This system consists of two 500 gallon mixing tanks and metering pumps which feed ponds A & B. Settled solids have been periodically cleaned from the ponds and placed in the mine-run material pile east of the production shaft headframe. In 1983 no addition of flocculents was required.

A total of 231.5 million gallons was pumped from the shafts in 1983, compared to 291 million gallons in 1982. Its deposition and use by month is given in Table 4-2. Flow metering of the NPDES discharge has been accurate to approximately 5-10%. For the years 1981 to 1983 the overall summary is:

	(10^6 gallons)		
	1981	1982	1983
Total water pumped from shafts	634	291	231.5
Water used, evaporated, etc.	164	30	13.0*
Water treated			
NPDES surface discharge	331	134	218.5
Reinjected	99	127	0
Sprinkler irrigated	40	0	0
Total treated	470	261	218.5

*12.8 used or stored and 0.2 lost to evaporation and seepage.

Further water management aspects are discussed in Section 7.2.

4.1.11 Hydrology Laboratory

This lab is equipped with all the necessary laboratory and safety equipment and supplies to ensure the proper preparation and testing of field water samples: pH, temperature, conductivity, dissolved oxygen, total suspended solids and fluoride. Samples for additional water quality parameter determination are labeled, preserved, and transported to Cathedral Bluffs' Grand Junction Laboratory for analysis or shipment to a commercial laboratory.

TABLE 4-2

1983 C-B WATER USAGE (10**8 GALLONS, * =ACRE FEET)

	USE	SOURCE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL YTD	TOTAL YRS TD
ALL SHAFTS	GLAND WTR	PUMP 6TA	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		190.6
			0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*		584.9*
*TOTAL ALL SHAFTS			.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		190.6
			0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*		584.9*
OFF-TRACT WTR USED POTABLE		TOWN	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		1.1
			0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*		3.3*
*TOTAL OFF-TRACT WTR USED			.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		1.1
			0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*		3.3*
TRACT WATER USED	BATCH PLNT	24X=25	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		2.5
			0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*		7.6*
	CONSTR	PONDS	.01	.02	.02	.00	.00	.00	.00	.00	.00	.01	.01	.01	.07	18.0
			0.03*	0.05*	0.05*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.02*	0.02*	0.02*	.20*	55.3*
	CONSTR	24X25	.00	.00	.00	.02	.02	.02	.01	.02	.02	.00	.00	.00	.11	1.8
			0.00*	0.00*	0.00*	0.07*	0.07*	0.07*	0.02*	0.05*	0.05*	0.00*	0.00*	0.00*	.34*	5.4*
	DUST CNTL	PONDS	.00	.00	.00	.00	.03	.00	.01	.00	.00	.00	.00	.00	.04	6.7
			0.00*	0.00*	0.00*	0.00*	0.09*	0.00*	0.04*	0.00*	0.00*	0.00*	0.00*	0.00*	.12*	20.5*
	EVP & LEAK	POND C	.00	.00	.00	.02	.07	.09	.01	.00	.00	.00	.00	.00	.20	144.8
			0.00*	0.00*	0.00*	0.08*	0.23*	0.28*	0.03*	0.00*	0.00*	0.00*	0.00*	0.00*	.61*	444.5*
	NPDES REL	PONDS	20.83	18.17	20.45	18.44	19.85	18.52	17.70	17.18	16.43	16.99	17.14	18.88	218.48	1,008.1
			63.91*	55.74*	62.74*	58.84*	61.21*	56.83*	54.30*	52.67*	50.42*	52.13*	52.59*	51.22*	873.40*	3,083.3*
	REINJECT	PONDS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		225.7
			0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*		682.6*
	SPR IRRIG	POND C	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		79.1
			0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*		242.6*
*TOTAL TRACT WATER USED			20.84	18.18	20.48	18.48	20.07	18.83	17.73	17.18	18.45	17.00	17.15	16.70	218.88	1,486.7
			63.84*	55.78*	62.79*	59.79*	61.60*	57.18*	54.39*	52.72*	50.47*	52.15*	52.62*	51.24*	674.69*	4,561.8*
WATER IN STORAGE	-	POND A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
			3.07*	3.07*	3.07*	3.07*	3.07*	3.07*	3.07*	3.07*	3.07*	3.07*	3.07*	3.07*		
	-	POND B	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15		
			0.46*	0.46*	0.46*	0.46*	0.46*	0.46*	0.46*	0.46*	0.46*	0.46*	0.46*	0.48*		
	-	POND C	.20	.20	.20	.17	.10	.01	.00	.00	.00	.00	.00	.00		
			0.61*	0.61*	0.61*	0.54*	0.31*	0.03*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*		
*TOTAL WATER IN STORAGE			1.35	1.35	1.35	1.32	1.25	1.16	1.15	1.15	1.15	1.15	1.15	1.15		
			4.14*	4.14*	4.14*	4.07*	3.84*	3.56*	3.53*	3.53*	3.53*	3.53*	3.53*	3.53*		
WATER PUMPED	-	33X-1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		4.3
			0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*		13.3*
	-	24X-25	.00	.00	.00	.02	.02	.02	.02	.02	.02	.00	.00	.00	.12	8.1
			0.00*	0.00*	0.00*	0.07*	0.07*	0.07*	0.08*	0.05*	0.05*	0.00*	0.00*	0.00*	.38*	24.7*
	-	32X-12	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		5.8
			0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*		18.0*
	-	V/E SHAFT	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		679.9
			0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*		2,083.1*
	-	PROD & SERV	21.19	18.62	20.83	19.82	19.88	19.10	19.75	18.87	18.19	18.89	17.98	18.08	231.38	1,044.4
			65.04*	57.14*	63.91*	61.13*	61.31*	58.60*	60.80*	57.81*	55.80*	57.86*	55.11*	55.41*	708.92*	3,204.7*
*TOTAL WATER PUMPED			21.19	18.62	20.83	19.94	20.00	19.12	19.77	18.89	18.20	18.89	17.98	18.08	231.49	1,741.5
			65.04*	57.14*	63.91*	61.20*	61.38*	58.67*	60.86*	57.86*	55.85*	57.86*	55.11*	55.41*	710.30*	5,343.8*

4.1.12 Permanent Mine Support Buildings

No change in 1983.

4.1.13 Off-Tract Engineering Studies

Union Oil Company of California

Approximately 51 tons of C-b Tract shale were processed in Union Oil Company's Unishale B pilot retort in Brea, California.

Bechtel

Bechtel, Houston, under contract to Cathedral Bluffs, performed engineering work that resulted in the preparation of a Level II/Level III design and cost estimate for the MIS underground and surface process facilities.

Fluor

Fluor, Houston, developed a process design package and a Level II cost estimate for the oil upgrading (OUG) facilities. Fluor, Houston, was also tentatively selected to provide services for Project management, design and engineering services for the OUG and offsite/utility facilities, procurement services, construction management and support, and operations support.

Stearns-Roger

Stearns-Roger (S-R), Denver, provided engineering services to develop a Level II design and cost estimate for the surface materials handling facilities. Also, several engineering activities were carried out by S-R in the area of aboveground retorting facilities.

Woodward-Clyde

Woodward-Clyde, Denver, under contract to Cathedral Bluffs, provided the geotechnical design basis for the Spent Shale Disposal System.

Commercial Testing & Engineering (CT&E)

CT&E provided field screening and analytical assistance to accurately assess shale fines production and screening problems due to moisture for the mining through primary crushing stages of the raw shale material.

Dames and Moore

Dames and Moore, Denver, under contract to Cathedral Bluffs, provided a geotechnical investigation of the proposed Plant sites. This information was provided to Bechtel, Fluor, and Stearns-Roger in order to design and estimate the cost of equipment foundations.

Cathedral Bluffs

Cathedral Bluffs, along with support from several engineering contractors, developed a Level II/Level III CB Phase 1 Design Basis and Cost Estimate for the Synthetic Fuels Corporation. This estimate was submitted to the SFC on August 15, 1983.

4.2 Off-Tract Facilities Description

4.2.1 Grand Junction Office

No change in 1983.

4.2.2 Grand Junction Laboratory

This laboratory, which is located approximately 4 miles west of the Grand Junction office at Horizon Court, analyzes shale, gas and water samples for the Cathedral Bluffs site. Routine samples are analyzed and reported within 3 to 4 weeks after receipt. Tests started in mid 1983 and will be continued during 1984 on pond liner materials to determine their stability. The personnel and essential equipment are planned to be relocated to the Cathedral Bluffs site in the near future.

4.2.3 Rifle Warehouse and Rail Siding

No change in 1983.

4.2.4 Rifle Parking Lot

No change in 1983.

4.2.5 Utility Corridors

No change in 1983.

4.3 Access/Service/Support Activities

4.3.1 Fuel Storage and Dispensing

The duel dispensing facility is designated as facility #16 on Figure 4-2. Fuel consumption during the year ws 7,830 gallons of #2 diesel; 16,540 gallons of gasoline; and 124,700 gallons of LPG as indicated on Table 4-3. No natural gas was used in 1983.

4.3.2 Surface Mobile Equipment Use

Dust suppressant (Coherex/water mix) was applied to roads as indicated on Table 4-3. Snow removal work continued as in 1982.

4.3.3 Communicatons

A mine phone communications system was completed with phones installed at each station in the service shaft, the mine shop, the service and production shaft elevators, the control room, and the electrical power substation.

4.3.4 Other Access/Service/Support Activities

Other access/service/support activities relate to: (1) roads and guard rails; (2) truck weighing facility; (3) sewage treatment facility; (4) pump gland seal water system; (5) fire water loop system; (6) pipelines; (7) helicopter pad; and (8) aerial survey. There was no additional work performed on these areas during 1983.

TABLE 4-3

1983 C-b Consumable Usage

	USE	UNITS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL YTD	TOTAL YRS TD
WTR TREATMENT-ACID	POND A&B	10**3 GAL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		115.97
DIESEL FUEL #1	-	10**3 GAL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		69.01
DIESEL FUEL #2	-	10**3 GAL	.76	.17	.81	2.28	1.25	.27	.08	1.08	.31	.31	.31	.22	7.83	447.40
GASOLINE	-	10**3 GAL	1.74	1.34	1.98	2.08	1.18	1.53	.88	.88	1.07	1.07	1.14	1.48	16.54	295.90
PROPANE	-	10**3 GAL	12.15	23.88	23.15	23.21	11.57	.00	.00	.00	3.55	1.78	.80	24.58	124.70	492.50
NATURAL GAS	-	10**3 MCF	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		785.96
DUST PALLIATIVE	-	10**3 GAL	.00	.00	.00	.00	.00	.00	2.00	2.00	4.00	.00	.00	.00	8.00	32.97
MINED SHALE	-	10**3 CU YD	.00	.00	.43	.43	.00	.00	.00	.00	.00	.00	.00	.00	.86	115.53
MINED SHAFT ROCK	-	10**3 CU YD	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		11.40
EXPLOSIVES	-	10**3 LBS	.00	.00	1.25	1.25	.00	.00	.00	.00	.00	.00	.00	.00	2.50	329.52
EXPLOSIVES FREQ.	-	10**3	.00	.00	.02	.02	.00	.00	.00	.00	.00	.00	.00	.00	.03	1.55
DISTURBED ACREAGE	-	ACRES	188.00	188.00	188.00	188.00	188.00	188.00	188.00	188.00	181.00	191.00	191.00	191.00		191.00
FLOCCULANT	-	10**3 GAL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00		1.55

4.4 Mining

4.4.1 Production Shaft

During 1983, work in the production shaft was limited to commissioning skip hoist A and maintenance work. Speed gates, limit switches, and other electrical controls were installed in the shaft for controlling the hoist in the automatic mode. Rope dividers were installed near the shaft bottom to limit the motion of the free hanging tailrope loops. The mine water pumping system in the shaft bottom was expanded to provide backup pump capacity. All guide ropes in the production shaft were cleaned and lubricated.

4.4.2 Service Shaft

Most work in the service shaft was associated with the hoisting conveyances. Hoist commissioning required that magnetic sensors or speed gates be located at many locations in the shaft for each conveyance. Rope dividers were placed near the shaft bottom to limit tailrope motion during hoist operation. A survey of guide alignment and cage plumbness was completed.

To provide access to the cage without the use of fixed guides, an extendable platform on the midshaft level was made operational. Shaft signal and underground communications systems were installed in the service shaft. The mine monitoring system was installed and a monitor placed in the control room.

4.4.3 Ventilation/Escape Shaft

No change in 1983.

4.4.4 Production/Service Shaft Station Development

A bulk sample of high grade oil shale was mined in 1983 on the upper level station near the service shaft (see Figure 4-8). Approximately 1,200 tons of rock were mined in two stages. The first activity involved obtaining a very high grade sample to test the Union pilot retort's ability to process high grade feeds. The second mining activity obtained a coarse shale sample which was used to determine fines generation during size reduction by a feeder breaker. Fines generated were conservatively within the design basis.

The feeder breaker was also tested as to maximum feed size. Large boulders of oil shale were provided by Exxon's Colony Project for the test. Union Oil leased the feeder breaker for a sustained test run to produce varied product sizing.

4.4.5 Mine Ventilation

The mine monitoring system installation has been completed during 1983. There are 26 sampling points to monitor methane concentration in the mine atmosphere and another 46 points monitor several functions such as air flow, fan operation, pump operation, and water levels.

The service shaft is equipped with a 75 hp fan plus a propane-fired intake air heater at the surface. At the lower level, twin 50 hp fans intake air from the bottom of the service shaft and blow it to the bottom of the production shaft; this air then exhausts to the surface.

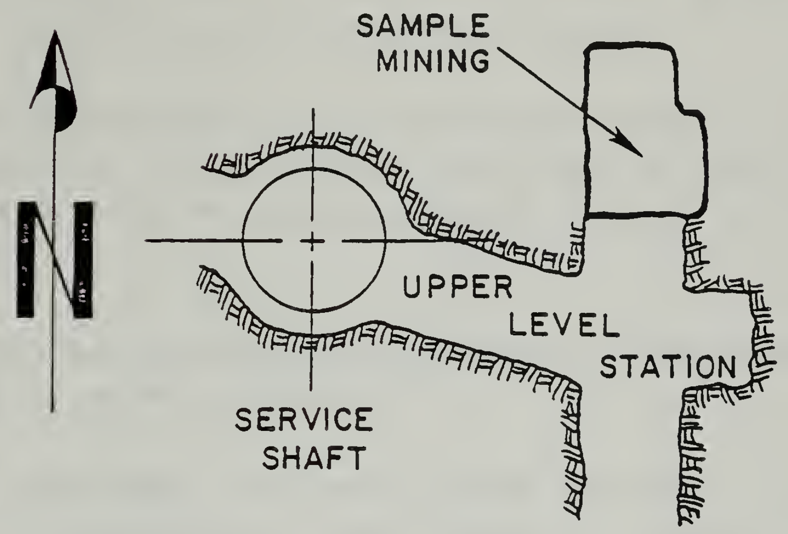
4.5 Geotechnical Program

4.5.1 Surface Drilling Data

A coring program was designed in 1981 which attempted to anticipate and satisfy both immediate and long-term needs of the project and was designed to supplement rather than duplicate existing information. Drilling for this program was initiated in 1981 and, due to the slowdown of CB activities in 1982, the second stage of this program was deferred until September 1983 with the drilling

BULK SAMPLE MINING LOCATION

PLAN VIEW - SCALE: 1" = 50'



CROSS SECTION - SCALE: 1" = 20'

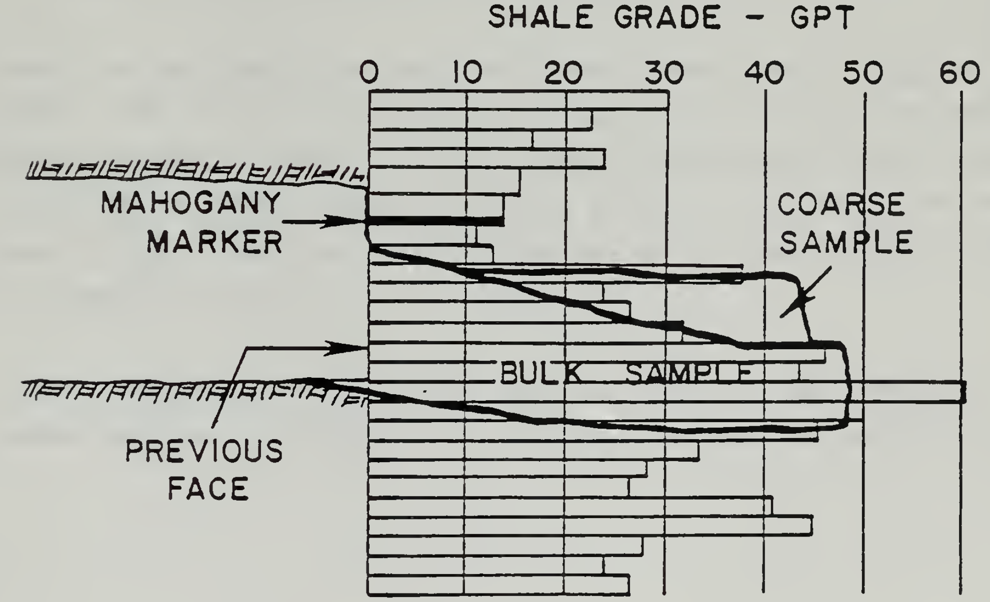


Figure 4-8

of 6 holes (see Figure 4-9 and Table 4-4). These holes were designed to fill data gaps on the Tract and provide detailed data in the proposed initial room and pillar and MIS mining areas. Two core holes (21Y-12 and 21Z-12) were drilled in the proposed R&P area and holes 44X-1, 14X-6, 43X-1, and 41X-12 were drilled in the proposed MIS area. Each well was to:

1) Provide additional data on the specific mining horizons for the geologic, hydrologic, and rock mechanics data base.

2) Be located stratigraphically in areas where questions of rock quality have arisen, i.e., valley bottoms vs. ridge tops. Well 44X-1 is located in the bottom of East No Name Gulch, whereas the other wells are on the ridge tops.

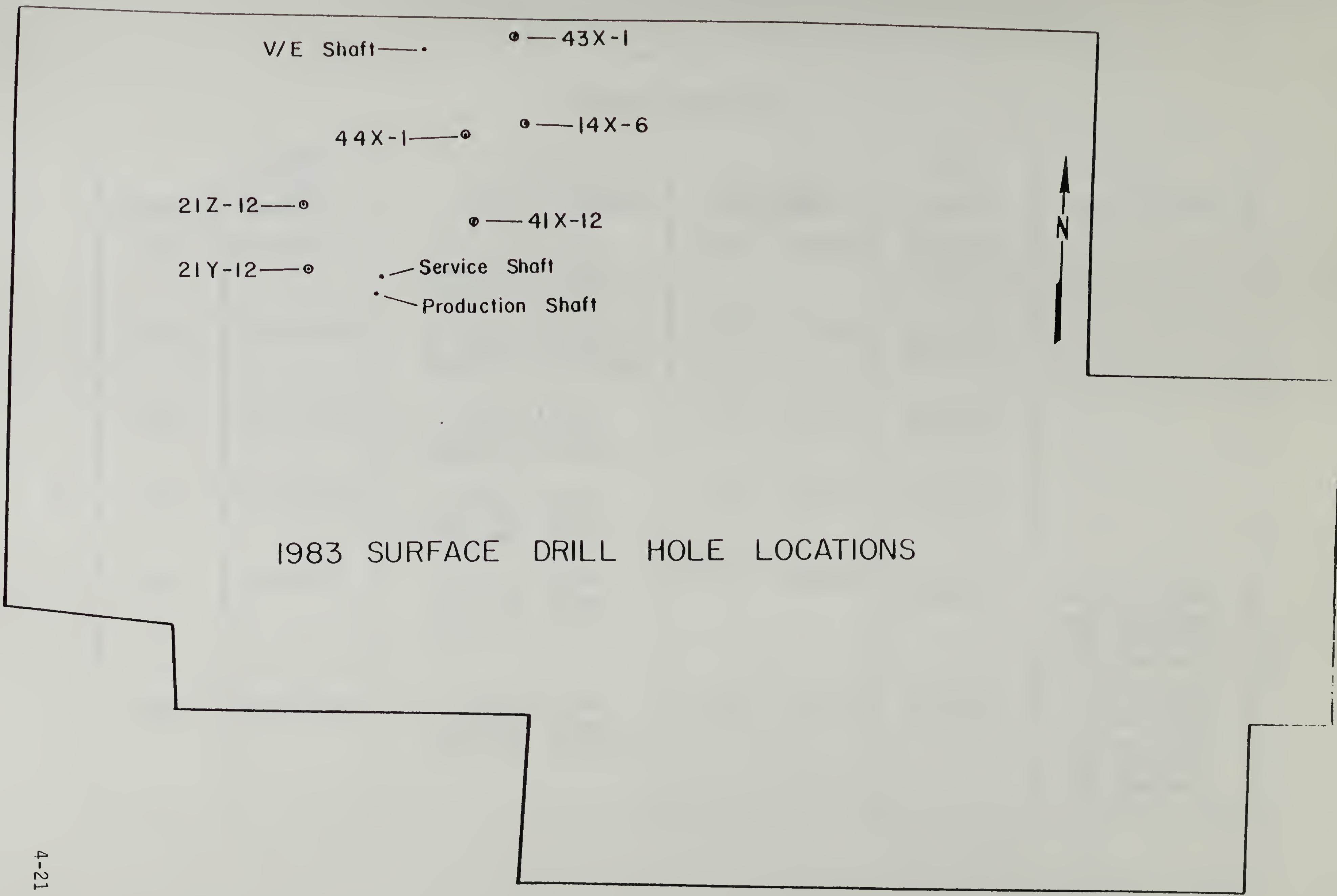
3) Provide detailed gas evaluation and gas production data along with water conditions in the mining horizons.

4) Provide closely-spaced core data (< 1500' spacing) to be used for geostatistical evaluation of grade variations, currently underway on existing CB data.

5) Provide hydrologic data and monitoring wells to observe early mine dewatering effects on the CB groundwater system.

Water and gas production were continuously monitored during the drilling of all holes. Two of the six holes were used to obtain data on short-term and long-term offgassing. Cores from the complete room and pillar interval of hole 21Y-12 and the MIS retort interval of hole 44X-1 were sealed in PVC 4" tubes and monitored for gas liberation over a given period of time. Analysis of these data will be completed in 1984.

After completion of drilling, each well was to be completed as a deep groundwater monitor. See Table 4-4 for status of these new wells in LPC3 zone.



V/E Shaft
43X-1
44X-1
14X-6
21Z-12
41X-12
21Y-12
Service Shaft
Production Shaft
N
1983 SURFACE DRILL HOLE LOCATIONS

Figure 4-9

TABLE 4-4

Surface Drilling Data

Designation	Surface Casing Depth/Dia.	Drilled Depth Interval @ Specified Diameter	Cored Length and Diameter	Date Started & Completed	Other Work Completed
21Z-12	40'/9-5/8"	0- 40' 12-1/4" 40-1203' 6-1/4" 1203-1457' 3-11/32"	254' 3-11/32"	9-13-83 to 10-06-83	
21Y-12	42.7'/9-5/8"	0-42.7' 12-1/4" 42.7-1251' 6-1/4" 1251-1473' 3-11/32"	222' 3-11/32"	10-11-83 to 10/27/83	
44X-1	43.5'/9-5/8"	0-43.5' 12-1/4" 43.5-1160' 6-1/4" 1160-1570' 3-11/32"	410' 3-11/32"	10-28-83 to 11-13-83	
41X-12	40.5'/9-5/8"	0-40.5' 12-1/4" 40.5-1262' 6-1/4" 1262-1680' 3-11/32"	418' 3-11/32"	11-14-83 to 11-29-83	
14X-6	44'/9-5/8"	0- 44' 12-1/4" 44-1239' 6-1/4" 1239-1672' 3-11/32"	433' 3-11/32"	11-30-83 to 12-09-83	4" casing-1638' + cemented 30 per-forations from 1285' to 1560'. (LPC3 Monitor)
43X-1	40.6'/9-5/8"	0-40.6' 12-1/4" 40.6-1242' 6-1/4" 1242-1658' 3-11/32"	417' 3-11/32"	12-09-83 to 12-17-83	4" casing-1638" + cemented 30 per-forations from 1264' to 1575'. (LPC3 Monitor)

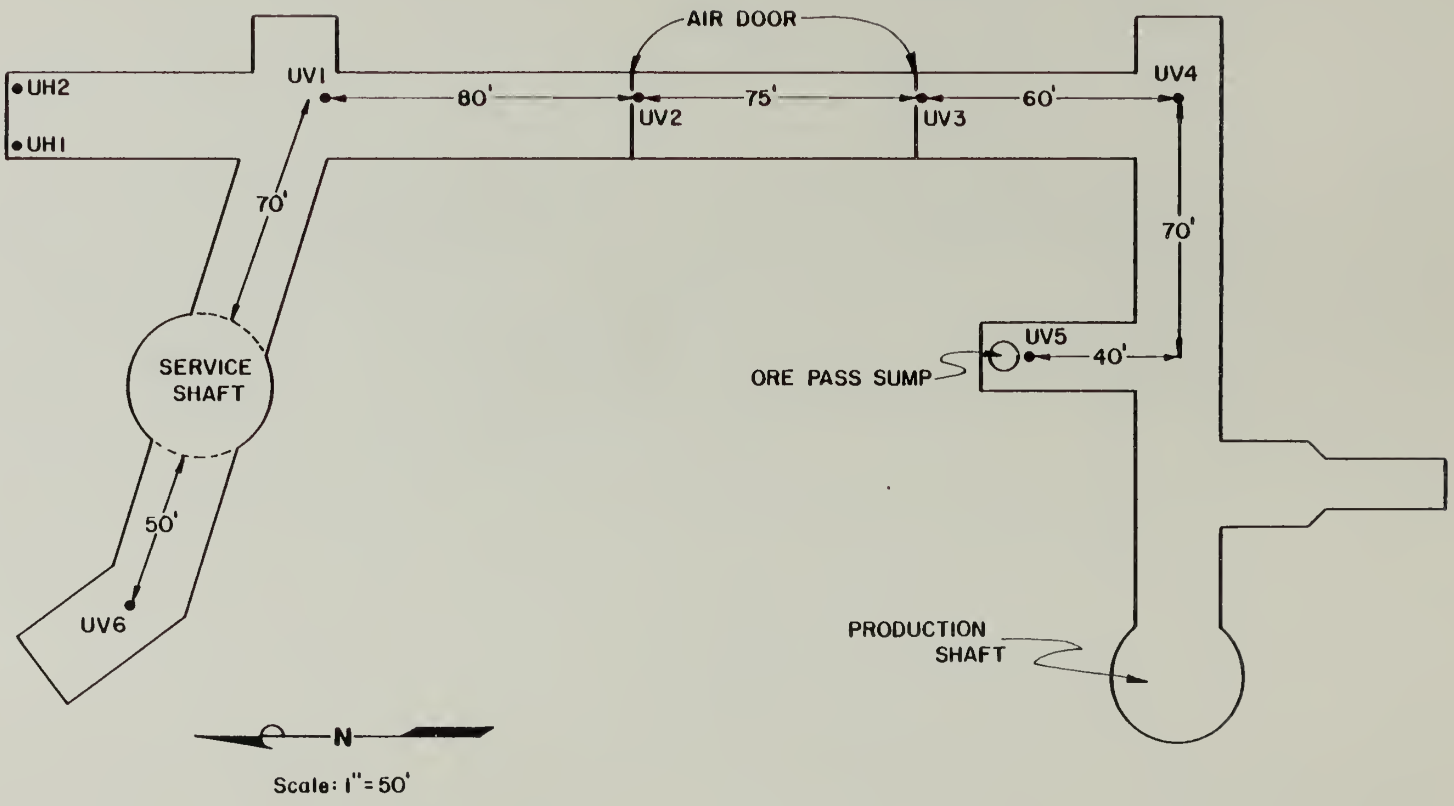
Two additional drilling programs were undertaken in 1983. The first was the drilling of three alluvial wells and one bedrock well north of C-b Tract around Spring S102. This is part of the cooperative effort of CB and the USGS Water Resources Division to obtain data to be used in development of the relationship of the bedrock-alluvial-surface water interactions. These three alluvial wells (A102-1, A102-3, and A102-4) were drilled and completed along with the bedrock well B102-3.

The other drilling program initiated in 1983 was a two-phased gas evolution, coring cooperative program between CB and the U.S. Bureau of Mines Methane Research Division at Pittsburgh, Pennsylvania. This program is presently in Phase II and will be completed in early April, 1984. The complete program involves:

1) Phase I - Two parallel horizontal holes (each 200 ft. long) are cored in the north heading of the service shaft in the upper void level (upper mahogany zone). See Figure 4-10. Holes are designated as UH1 and UH2. All core will be logged, marked, and then canned and all gas evolution monitored. Any water and/or gas encountered during drilling will be recorded.

2) Phase II - This involves coring of six vertical holes, each 40 ft. deep through the R&P mine zone, designated as UV1 thru UV6 on Figure 4-10. The core will be canned for total gas evolution studies along with Fischer Assay data for closely spaced geostatistical study of grade variation.

After completion of all drilling, cross-hole permeability studies will be initiated in the horizontal holes and in certain intervals in a few of the vertical holes. Each hole will then be equipped with pressure gauges for long-term monitoring until mining begins.



PLAN VIEW OF UPPER VOID LEVEL - SERVICE/PRODUCTION SHAFTS
SHOWING LOCATIONS OF THE GAS EVOLUTION, CORING PROGRAM SITES

Figure 4-10

5.0 PROCESSING

No shale oil processing facilities exist on the C-b Tract. Engineering studies related to processing are discussed in Section 4.1.13.

6.0 LAND DISTURBANCE AND RECLAMATION

The major reclamation activity of 1983 was the preparation of the CB Mined Land Reclamation Permit Amendment Application. Tests are currently being conducted on CB shale retorted via the Unishale B retorting process. These tests include further characterization of the spent shale and the hydrologic properties of the proposed spent shale embankment. They are deemed necessary to further define the proposed design of the spent shale disposal embankment. The test results are expected to be received and incorporated into the Amendment Application in time for an anticipated August, 1984 submittal date to the Colorado Mined Land Reclamation Board.

In April, 1983, the CB staff constructed a revegetation demonstration plot at the C-b Tract. This plot was constructed with a 60 ton sample of CB shale retorted via the Unishale B retorting process. Section 9.3.10 of this report gives a description of the plot as well as the results of the first year sampling.

Areas of disturbance through 1983 and the corresponding estimated acreages are listed in Table 6-1 and shown on Figure 6-1 (Jacket).

6.1 Disturbed and Reclaimed Areas

The areas of new disturbance during 1983 consisted of the six drill pads of the core sampling program. The coreholes are designated as 21Y-12, 21Z-12, 41X-12, 44X-1, 43X-1 and 14X-6. Each of the drill pads are approximately one-half acre in size, for a total of three acres of new disturbance bringing the total disturbed acreage to date to 191.

Two of the six coreholes have been converted to monitoring wells. Recompletion activities were not completed until late in the year; therefore, reclamation activities such as recontouring and seeding were not done in 1983. The other four wells are scheduled for completion in 1984. Reclamation activities on these wells will be completed in the fall of 1984.

TABLE 6-1

Estimates of Acreages Disturbed and Revegetated

Area[1]	Acreages Disturbed Before 1983	Acreages Disturbed During 1983	Acreages Revegetated Before 1983	Acreages Revegetated During 1983
1) Guard House & Truck Scale Area	2			
2) Sewage Treatment Plant & Road	2			
3) Heliport & P. R. Trailer	1			
4) Main Access Road	24			
5) V/E Shaft Area	14			
6) Proposed Dam Site (East No Name Gulch)	3		3	
7) Fill Material Area	12			
8) Explosives Storage	2			
9) Mine Support	73			
10) Raw Shale Embank.	12		1	
11) Rock Stockpiles	4			
12) Topsoil Stockpiles	13		11	
13) Water Discharge & Application Area	4			
14) Abandoned Access Road	10		10	
15) Permitted Areas				
16) Irrigation Pipeline	4		4	
17) Pond "C" Pipelines	2		2	
18) Drill Pads & Roads	6	3	4	
19) Raw Shale Demonstration Plot				
20) Processed Shale Demonstration Plot				
TOTALS	188	3	35	0

[1]Numerated Areas in column correspond to numerated areas on "C-b Tract Map" #AD-0039 Rev. 4, 1984, Figure 6-1 (jacket map).

No other areas were reclaimed in 1983; therefore, the total acres reclaimed during 1983 was zero.

6.2 Stockpile and/or Disposal Activities

Approximately 1,200 tons of raw shale were mined and crushed at the C-b Tract in 1983. From this a 150 ton sample was sent to Brea, California to be "test" retorted at Union Oil Company's Unishale B pilot retort plant. CB has not received the spent shale from this test.

This was the only mining activity to occur at the C-b Tract in 1983. The amounts and acreages of mine overburden, raw shale, and spent shale which are either stockpiled or disposed have not changed during 1983.

6.3 Disturbance/Reclamation Status

6.3.1 Graded Areas

The six corehole drillpads are temporarily in a graded condition. This increase of three acres increases the total area presently in a graded condition to 139 acres.

6.3.2 Topsoil Stockpiled

The topsoil from the drillpads was scraped off and stored at the edge of the pads for retopsoiling once the pads are recontoured. This will be done in the spring, 1984. Since this constitutes short term stockpiling (less than one year) it will not affect stockpiled topsoil volumes or acreages.

There was no change in stockpiled topsoil volumes and acreages during 1983.

6.3.3 Topsoil Replacement

No areas were retopsoiled in 1983.

6.3.4 Revegetation

No areas were revegetated in 1983.

6.4 Reclamation Management

No areas were seeded, mulched, irrigated, fertilized, fenced or transplanted during 1983. The topsoil stockpiles were evaluated for cover, production, and species composition. See Figures 6-2a thru 6-2e for progress on a typcial revegetation project from 1979 through 1983, that of the north topsoil stockpile. Data from sampling is presented in the January, 1984 Data Report. Revegetation demonstration plots on raw and spent shale were also sampled in 1983. Data are presented in the January, 1984 Data Report and analysis of the data is discussed in Section 9.3.10 of this report.

6.4.1 Associated Costs

The only associated cost for reclamation during 1983 was the labor involved in sampling and analysis of data. The approximate total cost for this labor was $550.00.

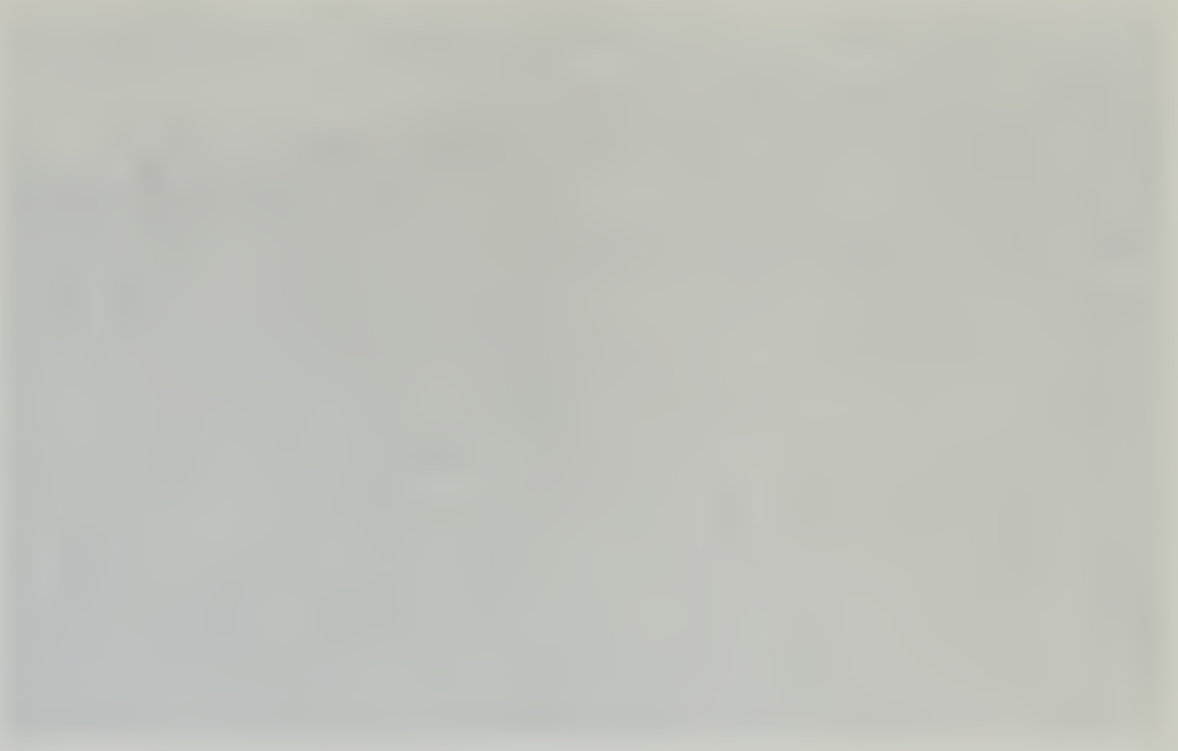
Figure 6-2A Revegetation Progress: North Topsoil Pile as Seen from Southeast Corner. September, 1979

Figure 6-2B August, 1980

Figure 6-2C August, 1981

Figure 6-2D July, 1982

Figure 6-2E July, 1983



7.0 ENVIRONMENTAL PROTECTION AND CONTROL

7.1 Air Pollution Control and Visibility

Principal activities in 1983 with the potential to affect air quality included truck transport along haul roads, and permitted open burning.

Comparisons of air monitoring measurements with ambient air quality standards are made in Table 9-7; compliance with these standards was achieved in 1983.

Air pollution permit conditions require use of control equipment and specified operating procedures. Permit status is summarized in Section 7.11 in tabular form showing permit purpose, agency, permit number and approval date.

CB holds a Prevention-of-Significant-Deterioration (PSD) Permit for the Ancillary Phase of MIS operations (defined in 1977 as up to 5,000 barrels/day nominally) from the EPA. Approval of an amendment to incorporate aboveground retorting and oil upgrading for a total capacity of 13,500 bbls/calendar day was received from the EPA in September, 1983.

The CB project obtained a Fugitive Dust Permit (C-11,454) (FD) from the Colorado Air Pollution Control Division in 1977, revised in 1980. Pursuant to this permit, CB paved the major access road to the Tract. This work was completed in August of 1978. PSD and Fugitive Dust Permits require dust control on haul roads by regular applications of water and dust palliatives. Water has been applied to the haul roads on an as-needed basis; dust palliatives have been applied since 1980. The applications of both water and dust palliatives are indicated in Tables 4-2 and 4-3.

In 1981, a permit was issued by the State of Colorado for a feeder-breaker to crush oil shale rock to minus 8-inch size. Maximum throughput is limited to less than 1,000 tons per hour and annual throughput is limited to 70,000 tons.

Water spray bars are utilized as the approved emission control devices. No permit was necessary from the EPA since the annual emission level does not exceed the diminimus level of 25 tons of dust per year based on an emission factor of 0.1 lb. of dust per ton of rock. The feeder-breaker was used in 1983.

With regard to visibility protection, no specific visibility - related regulations have been promulgated by the EPA. Visibility monitoring has been conducted since 1975, under request of the OSPO. No significant degradation in visual range has been noted since the inception of this program. See Section 9.3.5 for further discussion.

7.2 Water Management and Augmentation

The physical description of the water treatment facilities is given in Section 4.1.10. In 1983 discharge into Piceance Creek from Ponds A/B via East No Name Gulch under NPDES permit was the only part of the facilities utilized.

Table 4-2 summarizes water usage by month; annual and cummulative annual values are also shown. Water treatment rates (gpm) are further summarized on Table 7-1.

Regarding compliance with the NPDES permit criteria, effluent limitations under the old (1979) and the new (1983) permits are shown on Table 7-2. The Colorado Water Quality Control Commission did not specify a permit limitation for fluoride in the new permit since they did not judge it necessary to protect stream uses or stream standards for fluoride. In 1983, excursions under the old (1979) permit were reported to the State as follows:

Parameter	No. of Excursions
Fluoride	38
Total Dissolved Solids	9
Silver	1

Although fluoride exists in the discharge, at levels consistent with mine waters of the LPC_3 and LPC_4 aquifers, the maximum value in Piceance Creek at the downstream (Hunter Creek) station was 2.0 mg/l and average value for 1983 was 1.3 mg/l. For total dissolved solids (TDS), weekly values are reported; excursions

TABLE 7-1

Summary of Water Pumped and Used (gpm)

Year	Month	Water Pumped From Mine	Water Used, Stored, Evaporated	Water Treated(1) NPDES Discharges	Sprinkler (Land Application)	Reinjection	Total
1981	January	1,645	341	1,304	-	-	1,304
1981	February	1,663	596	1,067	-	-	1,067
1981	March	1,392	498	754	-	140	894
1981	April	1,122	278	583	-	261	844
1981	May	1,636	466	1,109	-	61	1,170
1981	June	1,221	136	745	48	292	1,085
1981	July	1,582	467	739	339	37	1,115
1981	August	1,550	275	942.	326	7	1,275
1981	September	617*	180	293	39	105	437
1981	October	627	184	8	-	435	443
1981	November	660	205	16	-	439	455
1981	December	772	298	-	-	474	474
1982	Janaury	664	181	-	-	483	483
1982	February	651	154	5	-	492	497
1982	March	535	90	-	-	445	445
1982	April	476	60	-	-	416	416
1982	May	663	87	-	-	576	576
1982	June	588	83	-	-	505	505
1982	July	560	20	540	-	-	540
1982	August	562	22	540	-	-	540
1982	September	532	7	525	-	-	525
1982	October	472	0	472	-	-	472
1982	November	460	2	458	-	-	458
1982	December	495	0	495	-	-	495
1983	January	475	8	467	-	-	467
1983	February	462	11	451	-	-	451
1983	March	467	9	458	-	-	458
1983	April	461	11	450	-	-	450
1983	May	448	1	447	-	-	447
1983	June	442	13	429	-	-	429
1983	July	442	45	397	-	-	397
1983	August	423	39	384	-	-	384
1983	September	421	41	380	-	-	380
1983	October	423	42	381	-	-	381
1983	November	416	19	397	-	-	397
1983	December	405	31	374	-	-	374

(*Starting September 1, 1981 V/E Shaft was no longer pumped and allowed to fill)
(1) Water Pumped = Water Used + Water Treated

TABLE 7-2

Effluent Limitations for 1979 and 1983 NPDES Permits

(Outfall 002, Ponds B or C)

	Maximum Concentration (mg/1)			
	1979 Permit		1983 Permit(3)	
Effluent Parameter	30-day Average	Daily Maximum	30-day Average	Daily Maximum
Flow (mgd)	N/A	(1)	N/A	N/A
Total suspended solids	30	45	30	45
Total dissolved solids	1,200	1,800	1,700	2,500
Total fluoride	N/A	9.0	N/A	N/A
Total boron	N/A	3.5	2.0	3.0
Total ammonia as nitrogen	N/A	1.3	2.4	N/A(2)
Total residual chlorine	N/A	N/A	N/A	N/A
Total phenol	N/A	0.2	N/A	N/A
Soluable aluminum	N/A	1.1	N/A	N/A
Total iron	3.5	7.0	11.0	22.0
Total cadmium	N/A	N/A	0.05	0.10
Total copper	N/A	0.24	0.04	0.08
Total mercury	N/A	0.00005	0.00005	0.0001
Total silver	N/A	0.00005	0.00053	0.0011
Total zinc	N/A	N/A	N/A	N/A

Oil and grease shall not exceed 10 mg/l in any grab sample nor shall there be a visible sheen. The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units. There shall be no discharge of floating solids or visible foam in other than trace amounts.

(1) The combined flow of all discharges shall not exceed one-tenth of Piceance Creek for the same day as measured at the USGS Gauging Station 09306061.

(2) Weekly max 3.6

(3) Permit received August 31, 1983; effective September 30, 1983

were monthly averages; weekly allowable peaks were never exceeded. The silver excursion was resampled since there was no apparant reason for the excursion, and the resample was in compliance.

In 1983 the Colorado Water Control Commission classified Piceance Creek and adopted stream standards for its various reaches. The reach of Piceance Creek near the C-b Tract (between Stewart Gulch on the east and Hunter Creek on the west) has been classified: Class II, Aquatic Life, Warm Water and Class II, Recreational and Agricultural.

In 1983 all outstanding permit criteria issues were resolved with the State. The new permit was issued September 30, 1983; there were no excursions in 1983 under the new permit. See Table 7-2 for the new permit criteria.

Planning of water storage projects proceeded in 1983, similarly to 1982, along two lines:

1) Yellow Jacket Study - this study has been funded by the State of Colorado and is restricted to the Yellow Jacket project and selection of storage sites on the White River or its tributaries above the confluence with Piceance Creek.

2) White River Study - this plan is a joint effort between industry and the Yellow Jacket Conservation District. Work includes evaluation of White River storage alternatives and delivery systems to cover projected Piceance Basin oil shale industry use, other mining and industrial project use, agricultural use and municipal use.

Highlights of the CB Water Augmentation Plan were given in the 1980 report. To the present time no water augmentation by CB for Piceance Basin users has been needed or required by the State Engineer.

7.3 Oil and Hazardous Substances and Associated Spill Contingency

The Spill-Prevention Control and Countermeasure Plan includes a description of the potential for accidental spills or release of oil as a result of the Lessee's development of the Tract and associated off-Tract pipelines and terminals. This plan summarizes the potential sources of accidental spills, reviews the current regulations and standards that would apply to the Lessee's activities, and presents the Lessee's Spill-Prevention Control and Contingency Plans for the plant and associated pipelines.

The hazardous substance section of the Spill Contingency Plan is not completed. It is scheduled for completion and implementation in 1984. The purpose of the plan is to provide technical, legal and procedural guidance in response to spills of substances which are deemed hazardous by the regulations. In the plan final form, response to instances involving spills of oil and hazardous substances will be combined.

7.3.1 Summary of Potential and Actual Spills During Construction

During construction activities, spills of diesel fuels and other fuels and lubricants are possible during transporation, loading, and unloading operations, both on-Tract and at construction staging areas and rail spurs. Dust suppressants and smaller amounts of miscellaneous chemicals used during construction activities also pose pollution threats if quantities of these materials reach drainages or flowing streams near the Tract. The trucking, loading, and unloading of fuels and chemicals during construction is a potential source of accidental spills. A program has been implemented to ensure that all transformers brought on Tract will not contain PCB's.

There were no reportable spills (see 7.3.3) requiring activities of the Spill Contingency Plan during the year.

7.3.2 Oil and Hazardous Substance Inventory

A list of oil and hazardous substances presently on-Tract is given on Table 7-3. The list identifies those both on-and off-Tract which would be classed as wastes if allowed to escape; locations are cross-referenced to maps in this report. Storage is consistent with Lease requirements.

TABLE 7-3

Oil and Hazardous Substance Inventory

Material Stored	Storage Site No.**	1979 Storage BBL	1980 Storage BBL	1981 Storage BBL	1982 Storage BBL	1983 Storage BBL
Plasticrete	15	50	50	90	1	1
Diesel Fuel	16	830	2,950	3,000	1,500	250
Gasoline	16	35	645	1,000	500	145
Motor Oil and Grease	*	0	0	70	50	20
Chlorine	15	10	10	0	0	0
LPG	*	190	850	837	595	305
Shale Oil	40	0	0	244	0	0
Sulfuric Acid	43	30	100	100	24	20

* Stored at numerous locations on construction site.

** See Figures 4-2 and 4-3.

7.3.3 Notification Under the Response Plan

In the event of an accidental spill of oil or hazardous substance in quantities greater than those specified by the regulations, various governmental entities must be notified. Spills consisting solely of oil are reportable when they reach or have the potential of reaching a waterway in quantities which cause a film, sheen or discoloration of the water. Spills involving hazardous substances are defined to be reportable when they occur on the land or reach a waterway in quantities exceeding those specified by the regulations (40 CFR 117.3).

Notification	Spill Situation
National Response Center (NRC)	"Reportable Spills"
Regional Response Center	When the NRC cannot be contacted
Colorado Department of Health	"Reportable Spills"
Colorado Division of Wildlife	Danger to fish, etc., in surface water supplies
Water Quality Control Division, Colorado Department of Health	Contamination of water supplies
Colorado Highway Department	Move vehicles, control traffic
Oil Shale Project Office	All spills
BLM, USFS	Certain cases
Local, city, fire, police, health department	Major spills

7.3.4 Spill Response Team

All spills not involving the product oil pipeline will be responded to by an in-plant spill response team which will be especially organized and trained for this purpose. A Spill Response Coordinator (SRC) has the primary responsibility for deciding the action required and assembling the necessary team elements (see Table 7-4).

TABLE 7-4

Spill Response Team Members

Spill Response Coordinator	D. Perdock
Cleanup Coordinator	S. L. Stringer
Government Liaison Coordinator	E. B. Baker
Public Relations Coordinator	R. E. Thomason
Legal Coordinator	J. M. Badger
Environmental Protection Coordinator	E. B. Baker
Procurement and Logistics Coordinator	T. L. Carruthers
Document Coordinator	T. H. Pysto
Accounting Coordinator	L. G. Barth
Training Coordinator	J. A. Fox
Safety and Security Coordinator	E. L. Brake

7.4 Waste Disposal

The 9,000 gallon-per-day sewage treatment facility was not in operation during 1983. At present, the sewage is being disposed via porta-johns; and an approved sewage system that has been in operation for eight years is utilized to dispose of that from the C-b offices. Solid waste (trash) accumulated in waste bins was trucked off-site as frequently as necessary to approved landfills in Meeker; total amount for 1983 was approximately 400 cubic yards.

7.5 Erosion Control

There were no new erosion control structures constructed in 1983. Nine erosion control basins remain at the C-b Tract controlling runoff from disturbed sites. Sediment was mucked out from these structures in the fall of 1983. They were monitored throughout the year for possible leaks.

7.6 Historic, Scientific, and Aesthetic Values Protection

As part of the Lessee's plan to protect these assets, archaeological and scenic-value studies have been undertaken on the Tract and surrounding area and reported in prior years; no new studies were conducted or needed. In view of the relatively light Tract activities in 1983 no archaeological "findings" were expected, nor have they occurred.

7.7 Health, Safety and Security

7.7.1 Program and Services

7.7.1.1 General

All levels of the CB management have a complete commitment to employee protection. Although all risks cannot be completely eliminated, CB will provide and maintain working conditions which are as safe and healthful as modern state-of-the-are safety and industrial hygiene practice can provide. A comprehensive health, safety, and security program will be developed and implemented to ensure that these objectives are achieved. New employees are required to receive health and safety training prior to being assigned work duties.

Currently the Health and Safety Department consists of four people, the Manager (at Grand Junction), and three (night) security guards at the C-b Tract. Four trained Emergency Medical Technicians remain on the CB staff for emergency treatment. St. Mary's Flight for Life aircraft helicopter is available for extreme medical emergencies twenty-four hours a day.

7.7.1.2 Manhours/Accident Frequency Rate

Following are figures depicting the manhours and accident frequency rate for 1983 at the C-b Tract:

	Manhours	Reportable Accidents	Incident (b) Rate
CB	56,254	2 (a)	7.11
Contractors	99,881	0	0.00
TOTAL	156,135	2	2.56

7.7.1.3 Inspections and Violations

Cathedral Bluffs had a total of nine MSHA inspection days during 1983; there were no State inspection days. The number of citations received during 1983 was three, all of which have been resolved.

7.7.2 Possible Health Hazards

7.7.2.1 Dust

Dust is controlled on unpaved sections of roadways by the application of water and/or dust suppressant. Dust is controlled during rock drilling

(a) One of the reportable accidents is classified as an occupational illness (industrial tendonitis) rather than an accident

(b) IR - Incident Rate = $\frac{\text{No. of Reportable Accidents} \times 200{,}000}{\text{Hours of Employee Exposure}}$

operations by the use of water. Although there have been no surveys conducted yet to determine full-shift mine employee exposure to dust, it is not anticipated that problems exist in this area. Were dusty conditions to be encountered, the condition would be mitigated by changing ventilation, use of water sprays, or a dust palliative. Respirators would be used if compliance with standards could not be achieved.

7.7.2.2 Noise Control

Occupational noise control for employee protection is accomplished where feasible by equipment design. When this approach is not feasible, or when engineering design does not reduce noise levels below the maximum allowable limit, all exposed persons are required to wear ear protection.

7.7.3 Fire Control

Fire control training has been provided for both surface and underground situations.

The fire control systems utilized at the C-b Tract include the following:

- Dry chemical hand-held and wheeled fire extinguishers for protecting all buildings, including headframes.

- A twin agent (dry chemical/water foam) trailer extinguisher for large fire protection.

- A portable water tank (trailer mounted) available for use in extinguishing brush fires that might develop on site.

7.7.4 Gas

The shafts were classed as gassy on January 2, 1980 by the Mine Safety and Health Administration (MSHA). During 1983, preshift and on-shift examinations for methane at all working places underground continued around the clock in accordance with MSHA regulations. Logs of that activity are kept on site. Samples of the mine atmosphere for gas chromatograph analysis were taken intermittently throughout the year. No hazardous concentrations of methane were detected during 1983.

7.7.5 Explosives Handling and Storage

Explosives when needed for mining and surface construction use are stored in remotely located surface magazines (facility #63, located on Figure 4-6) which meet the criteria of the appropriate regulatory agencies. Explosives handling and transportation from magazine to the work site are conducted only by experienced, trained workers. Damaged and outdated explosives are burned in a remote location on Tract by the safety personnel under appropriate permit.

7.8 Fish and Wildlife Plan

7.8.1 Objectives of the Fish and Wildlife Protection Plan

Mitigation plans included in the Fish and Wildlife Plan were reviewed and updated. New possible projects include experimental seedings on south facing slopes and a serviceberry brush beating south of C-b Tract.

7.8.2 Stream Classification

The stream standards and classifications for the "lower Colorado," including Piceance Creek, were officially approved by the State of Colorado in 1983.

7.8.3 Mitigative Actions

7.8.3.1 Brush Beating

The 1980 brush beating areas were sampled for deer and lagomorph abundance. Deer pellet density differences between treatment and control areas were nonsignificant ($F = 0.31$; df 1, 7; $P > 0.50$). Results of lagomorph abundance studies still indicate lower frequencies of lagomorph pellets in the brush beaten plots vs. control areas. Results of 1983 studies are similar to previous years' results.

7.8.3.2 Deer Reflector Study

During the 1983 season, six deer were killed when the reflectors were in operation and 11 deer when they were covered. This brings the two year total to eight deer killed while the reflectors were operational and 14 when they were covered for a total of 22 deer killed in the reflector area. This number is still too small to draw any significant conclusions. At least 100 deer are needed to be able to test for a significant difference at the 90% confidence level. The study will be continued for the 1984 field season.

7.8.4 Springs Development

No additional springs or stock tanks were built by CB this year. Existing tanks were kept full during the appropriate seasons (early summer and fall).

7.8.5 Future Possible Mitigation Projects

Several mitigation projects have been proposed and approved which include: brush beating (crushing and cutting sagebrush, followed by reseeding with more desirable species), approved burning and plot fertilization, selected species planting in chained areas, fencing for improved cattle distribution, additional stock tanks and water wells, and proposed dams for water storage with potential for waterfowl wetlands and fishery habitat. The implementation of mitigation projects will depend on construction activities, success of past mitigation projects and development of new mitigation techniques. The area selected for beating (serviceberry - south of C-b Tract) was inspected and six transects for browse utilization, deer density and lagomorph abundance were established.

7.9 Off-Tract Corridors

No additional corridors were developed this year. Planning for future needs continued, i.e., coordination with BLM to identify CB needs. During 1983 the BLM produced a draft EIS for the Resource Management Plan of Piceance Creek which includes a master corridor plan compatible with CB needs.

7.10 Abandonment

The Abandonment Plan is contained in Supplemental Material to the Detailed Development Plan Modification submitted July, 1977. The plan is still valid. It will be updated in the Revised Detailed Development Plan (RDDP) in 1984.

7.11 Permit Status

A CB Permit Status Report of all required environmental permits and approvals for current and near-term construction operations obtained to date is presented on Table 7-5 including the following categories: air, water, land, and other.

7.12 Environmental Assessments

Tenneco and Occidental maintain a policy which requires annual assessments for environmental compliance. Environmental assessments or systems reviews have been conducted regularly with the following objective:

> The primary objective of a systems review program is to assess and improve the overall protection performance of Cathedral Bluffs Shale Oil Company through periodic appraisal of major operating facilities and support systems from Grand Junction.

The assessment team inspected the CB facility on May 17, 1983 and found the operation to be in compliance with all pertinent environmental regulations. At this time the team concluded there are no unreasonable or extraordinary environmental risks as a result of the present operating mode of the site.

TABLE 7-5
CB PERMIT STATUS REPORT
CURRRENT PERMITS/NOTICES

Permit Title	Purpose	Permitting Agency	Permit No.	Date Submitted	Date Approved	Date of Expiration	Remarks
Air							
1) PSD	For Ancillary Development of 5000 B/D MIS facility	EPA	N/A	10/17/77	12/15/77	N/A	Construction commenced 1978.
2) PSD	12,000 B/D AGR 13,000 B/D OUG	EPA	N/A	12/29/82	9/26/83	N/A	
3) APENs (26)	AGR/OUG Emission Sources	CAQCD	82RB410 (1-26)	12/29/82	10/15/83	N/A	
4) Fugitive Dust Permit	Surface disturbance for construction of shafts & support facilities	CAQCD	C-11,454 (FD)	6/27/77	12/28/77 Rev 8/05/80	Indefinite	
5) Emission Permit	Concrete Batch Plant	CAQCD	C-11,931	5/18/78	6/23/78	Indefinite	
6) Open Burning Permit	Dynamite disposal	CAQCD	1860-0B-0004	2/83	3/83	4/84	Permit has annual renewal requirement.
7) Emission Permits (4)	Natural gas generators	CAQCD	C-12,255 (1-4)	12/04/78	3/15/79	Indefinite	
8) Emission Permit	Feeder Breaker	CAQCD	C-13,244 (FD)	3/06/81	4/20/81 (State) 5/18/81 (EPA)	Indefinite	

TABLE 7-5

CB PERMIT STATUS REPORT

CURRENT PERMITS/NOTICES

Permit Title	Purpose	Permitting Agency	Permit No.	Date Submitted	Date Approved	Date of Expiration	Remarks
Water							
1) NPDES	Water discharge to Piceance Creek	CWQCD	CO-0033961	8/19/77	5/27/79		
				Rev. 6/30/80	12/1/80		
				New appl. 6/30/82	9/30/83	5/31/88	
2) SPCC	To comply with the Clean Water Act	CWQCD, OSPO, EPA		11/79	Not required	Update required every 3 years	Revision submitted 10/83.
3) Water Augmentation Plan	Depletion mitigation	Water Court	W-3492	8/31/77	5/21/79	Project Life	Detailed plan of augmentation due 4/85.
4) Well Permits (34)	Covers permits for 29 wells and 5 shafts filed under Augmentation Plan for any beneficial use.	State Engineer	W-3493	8/31/77	5/21/79	N/A	
5) Sewage Plant Site Approval	Sewage plant	CWQCD	Site 2852	8/06/80	8/28/80		Site transferred to existing package plant.
6) Sewage Plant	Sewage disposal	CWQCD	Site 2852	9/22/80	11/03/80	Indefinite	

TABLE 7-5

CB PERMIT STATUS REPORT

CURRENT PERMITS/NOTICES

Permit Title	Purpose	Permitting Agency	Permit No.	Date Submitted	Date Approved	Date of Expiration	Remarks
Land							
1) DDP & MDDP	Lease compliance	USGS/OSPO	N/A	2/77	8/77	Life of Lease	1983-84 Interim Plan approved 2/25/83.
2) Monument Peak Right-of-Way	Microwave communications	BLM	C-25677	7/31/77	10/20/77	10-19-2007	Annual rental payment required 10/84.
3) Rights-of-Way	Monitoring wells and access roads for SG-18, 19,21,A5A,Federal 2-B, TG2-3,TG2-1,71-3,71-5 and visibility site	BLM	C-36377 (Wells and Road ROW)		6/15/83	6/15/86	Annual payment required (6/15/84). Added visibility site 1/84.
4) Mined Land Reclamation Plan	Surface disturbance reclamation	CMLRB	77-530	11/07/77	5/23/78	Life of Project	Covers MIS development and 710 acres surface disturbance. Amendment required for AGR spent shale disposal prior to construction of AGR processing facilities. Annual reclamation report and fee submitted 3/16/83.
5) Special Use Permit	Permanent zoning	Rio Blanco County		10/10/78		indefinite	Follows original DDP, includes AGR. Status confirmed by resolution 7/5/83. Impact analysis is included in 1983 Major Development Permit application for addition to OUG and construction housing.

TABLE 7-5

CB PERMIT STATUS REPORT

CURRENT PERMITS/NOTICES

Permit Title	Purpose	Permitting Agency	Permit No.	Date Submitted	Date Approved	Date of Expiration	Remarks
Solid Waste							
Resource Conservation and Recovery Act (RCRA)							
1) Notice of hazardous waste activity	Generate & ship hazardous waste	EPA	EPA ID# COD 000 716530	8/18/80	N/A	N/A	There are no current hazardous waste activities.
Other							
1) Notice to FAA of Proposed Construction	Structures over 200 ft	FAA		8/18/78	None Required	N/A	Proper notification made. No further action needed.
2) Heliport Location	Heliport construction	DOI FAA		11/8/79	N/A	N/A	
3) Radioactive Materials License	Operate neutron moisture probe for soil moisture monitoring of spinkler plots.	Colo.Dept. Health	Colo 437-01	5/01/80	6/28/80	6/31/85	Source tested every 6 months.
5) TSCA-Inventory of Chemical Substances	Registration of shale oil	EPA	N/A	4/26/78	N/A	N/A	Raw shale oil is on the inventory of existing chemical substances.

8.0 SOCIOECONOMIC ACTIVITIES

8.1 Workforce

The CB Project workforce remained relatively constant during 1983. A total of 20 employees worked at the C-b Tract throughout the year. The Grand Junction office employed 67 persons at the beginning of the year and 64 at the end of the year.

8.2 Population

The populations of the Rifle and Meeker areas continued to decline during 1983, as the local economy continued to suffer from a lack of new employment opportunities.

8.3 Transportation

Highway traffic in the area has declined significantly from the 1980-1981 period. The average daily traffic count in 1983 along the Piceance Creek road near the C-b Tract was only one-third as high as that in 1981 at the same location.

Commercial airline transportation from Rifle was discontinued in 1983.

8.4 Housing

The only housing which the CB Project has retained in the area is the 103 space Kings Crown Mobil Home Park in Rifle. Space in this park is available to the general public. Vacancy rate in 1983 was approximately 10%.

Ongoing discussions were held with the City of Rifle concerning the annexation of the 113 acre Condon Property, owned by CB. This property will eventually be annexed, and five acres in the southwest corner of the property will be dedicated for use as a site for the construction of an indoor recreation center.

A proposal to construct a temporary on-site housing facility to house Project construction employees was submitted to Rio Blanco County as a part of the Master Development Plan Application. The proposal includes a mix of recreation vehicle space and motel-style units with a maximum of 850 dwelling units. A Housing Master Plan for the Project was also completed.

8.5 Socioeconomic Mitigation

In mid November, CB submitted the Major Development Permit Application to Rio Blanco County. The Application contained a comprehensive socioeconomic impact assessment based upon the current development schedule. The preparation of this analysis involved discussions concerning potential socioeconomic impacts and mitigation strategies with sixteen local government jurisdictions in Rio Blanco and Garfield Counties.

CB continued to participate in the Cumulative Impacts Task Force, an organization of local government, state government and industry, working to identify the cumulative socioeconomic effects of the energy industry.

8.6 Community Donations

Table 8-1 lists the budgeted contributions made by CB to various community projects in 1983.

TABLE 8-1a

Cathedral Bluffs
Contribution Status Schedule
As Of December 31, 1983

	Amount
City of Rifle	$ 2,500.00
City of Meeker	1,000.00
Meeker Hospital District	1,000.00
Meeker Recreation District	400.00
Flight for Life	2,500.00
Mesa County United Way	2,000.00
Garfield County United Way	970.00
Grand Junction Civic Organizations	1,325.00
St. Mary's Project Critical Care	5,000.00
Miscellaneous*	1,455.00
TOTAL	$18,150.00

*See Table 8-1b

TABLE 8-1b

Cathedral Bluffs
Miscellaneous Contribution Listing
As Of December 31, 1983

	Amount
Cenikor	$ 150.00
Colorado State Mining Championship	300.00
Rio Blanco County 4-H Livestock Sale	500.00
The Freedom Fighter	305.00
Community Concert Association	200.00
TOTAL	$1,455.00

9.0 ENVIRONMENTAL MONITORING

9.1 Scope

The Environmental Baseline Period for Oil Shale Tract C-b covered the period from November 1, 1974 to October 31, 1976. Results have been reported in nine Quarterly Data Reports, eight Quarterly Summary Reports, C-b Annual Summary and Trends Report (1976), and a 5-volume Environmental Baseline Program Final Report (1977), all submitted to the Oil Shale Project Manager.

From November 1, 1976 through August 31, 1977, the C-b Tract was under a period of suspension of the Federal Oil Shale Lease. The monitoring conducted during this period was executed under a program known as the Interim Monitoring Phase. Environmental data for this time period were submitted to the Oil Shale Project Office (OSPO) on October 14, 1977 (Interim Monitoring Report #1). The Interim Monitoring Period was later extended by the OSPO to cover the period from September 1, 1977 through March 31, 1978. Data for this time period were submitted to the OSPO on May 15, 1978 (Interim Monitoring Report #2). The Development Monitoring Program was initiated in April, 1978. The Development Monitoring Program for Oil Shale Tract C-b was submitted to the OSPO in a document dated February 23, 1979 and approved by the OSPO on April 13, 1979 subject to thirteen Conditions of Approval contained in the approval letter. Development Monitoring again reverted to Interim Monitoring status in March, 1982 as approved by the OSPO and has continued at that level to date. Actually an Interim Development Program and Schedule were approved on July 22, 1982 as DDP amendments. Interim monitoring has recently been extended through 1984 by the OSPO. Semi-annual environmental data reports are submitted every January 15 and July 15.

The Interim Monitoring and Development Montoring Programs have been reduced and changed from the Environmental Baseline Monitoring Program in many areas. Therefore, emphasis is now placed on key indicators of environmental quality and/or change.

9.2 Purpose

The purpose of the Annual Report is to fulfill the requirement of the Lease to provide the OSPO with an annual summary of environmental monitoring. The Development Monitoring Plan states the following objectives with respect to environmental monitoring:

> The purposes or objectives of environmental monitoring as defined in Section 1 (C) of the Lease Stipulations are to provide: (1) a record of changes from conditions existing prior to development operations, as established by the collection of baseline data, (2) a continuing check on compliance with the provisions of the Lease and Stipulations, and all applicable federal, state and local environmental protection and pollution control requirements, (3) timely notice of detrimental effects and conditions requiring correction, and (4) factual basis for revision or amendment of the Stipulations.

The approach taken utilizes the simple, multicomponent, conceptual model shown on Figure 9-1. The "outputs" or actions constitute the monitoring plan and its implementation (findings) as a result of monitoring (Box 4). "Inputs" consist of the environmental data base, the Lease Environmental Stipulations, the details of Tract operation, and applicable local, state, and federal regulations (Box 1). The mid-component or "decision matrix" (Box 2) consists of the three major criteria to which candidate variables for monitoring are subjected (relatability, observability, and measurability). The selected variables in the Program which are "screened" by these criteria become known as indicator variables. A significant feature of this conceptual model is its feedback capability. That is, variable levels (or magnitudes) are assessed against "expected" levels (Box 5). In the event that high levels are obtained, a "system dependent" mode of either more intensive monitoring, use of additional stations, or added variables (or all three) is triggered as illustrated in Box 6. Conversely should low levels continue, it could lead to less intense schedules or reduction of variables, or both. Feedback from the program results to date to obtain improved inputs ensures continual review and refinement of the monitoring programs as additional information is collected and analyzed. This is a provision

[illegible]

[illegible]

[illegible]

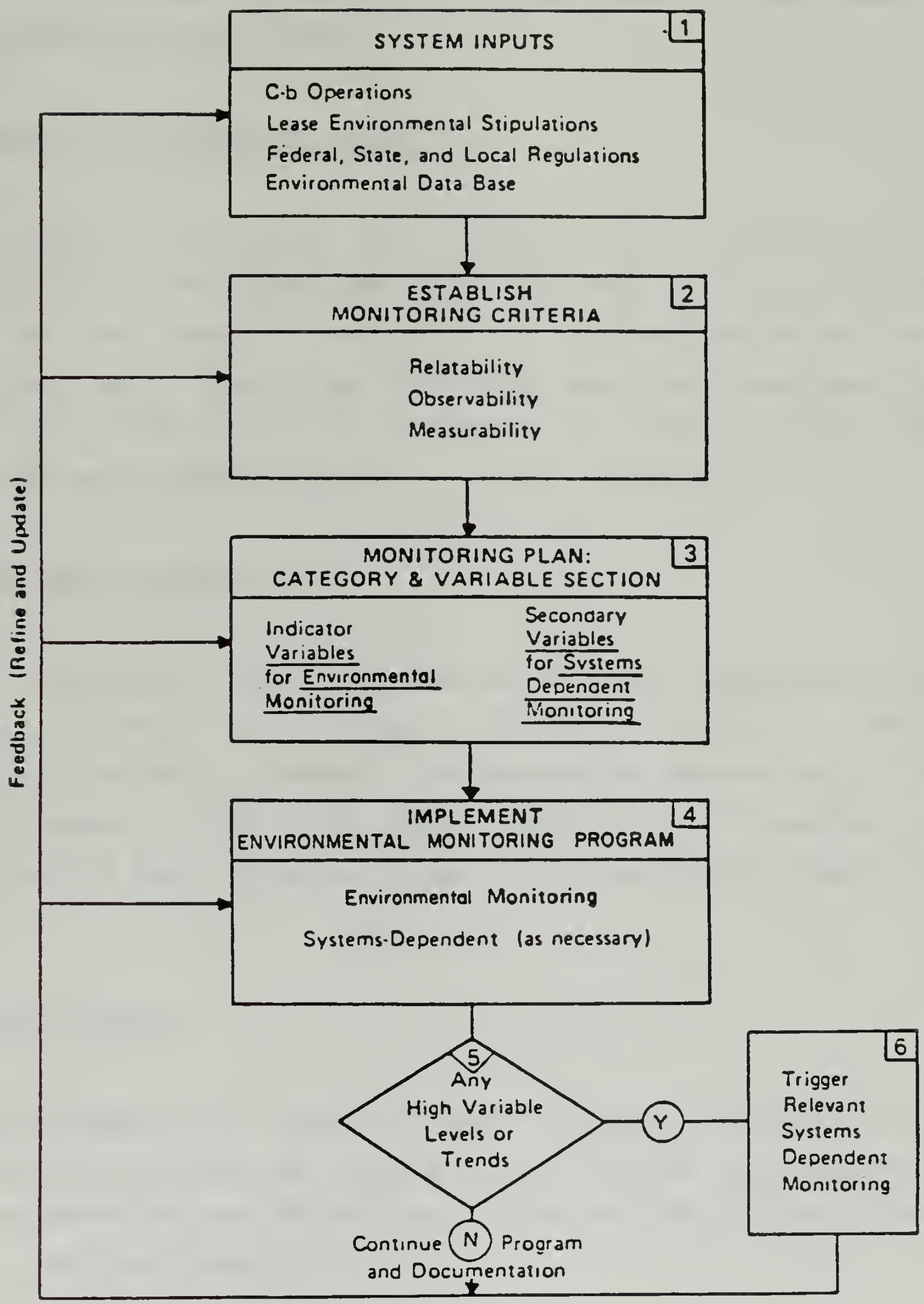


Figure 9-1

Conceptual Approach to Environmental Monitoring

not only for the evolution of the monitoring programs in terms of methods used in collecting and analyzing data and for refining sampling frequencies and locations, but also a provision for factoring in the phases of development and their subsequent effects on the system.

9.3 Summary of Environmental Monitoring

Environmental monitoring and analyses are continuing on Tract C-b. Development activities commenced within the past six years have resulted in activity on the Tract in the form of off-road vehicular use, facility construction, shaft sinking and outfitting associated headframes, and traffic into and out of the area. All activities have been conducted within strict adherence to environmental, permit, and lease regulations.

9.3.1 Indicator Variables

The environmental monitoring program has been brought into sharper focus with the identification of Class 1 indicator variables. These are key environmental variables collected at representative stations in at least monthly sampling frequency. Time series plots, generated by the computer from the data base for many of these variables, appear in the 6-month Data Reports submitted to the OSPO.

9.3.2 Tract Imagery

Tract imagery, in forms of color infrared panoramic photographs of vegetation around springs and seeps and use of Landsat for assessment of general vegetative condition, was discontinued in 1982 and 1983 in view of decreased Tract activity, with OSPO approval.

The frontispiece is a color reproduction of a color infrared (CIR) photograph of the CB vicinity taken on October 4, 1982 to an original scale of 1:58000 as part of the National High Altitude Photography Program (NHAP), a program coordinated by the USGS. Lands irrigated by Piceance Creek (on the north of the photo) and by natural springs appear as red, whereas non-irrigated, senescent or cropped vegetation appears greenish at this time of year; conifer forests are "mottled" darker green to black; small water bodies appear as black; bare soil, dirt roads and disturbed areas are yellowish. The C-b Tract is almost in the center of this photo; compare the photo with Figure 2-2. Both headframes are clearly visible.

9.3.3 Hydrology and Water Quality

The environmental monitoring program provides hydrologic and water quality data for the purpose of evaluation of potential impacts. Streams, springs, seeps, alluvial and bedrock aquifers, shafts and impoundments are presently monitored. The monitoring station locations are shown in Figures 9-2, 9-3, 9-4, and 9-5 for these programs.

The simplified two-layer aquifer concept that guided the measurements of flows and levels during the early monitoring program has evolved through study and analysis to the more detailed system in Figure 9-6. The revised concept identifies six general stratigraphic zones: Upper Uinta (UUN), Lower Uinta (LUN), Upper Parachute Creek 1 (UPC_1), Upper Parachute Creek 2 (UPC_2), Lower Parachute Creek 3 (LPC_3), and Lower Parachute Creek 4 (LPC_4). The LPC_3 interval includes the zone to be mined and dewatered. Also shown on the figure is a possible depth of both a room and pillar mine and a modified-in-situ retort, although neither exists at present.

Two items potentially affect the hydrologic monitoring program and its results: intentional cessation of dewatering of the V/E shaft and water management practices. Each are discussed in turn.

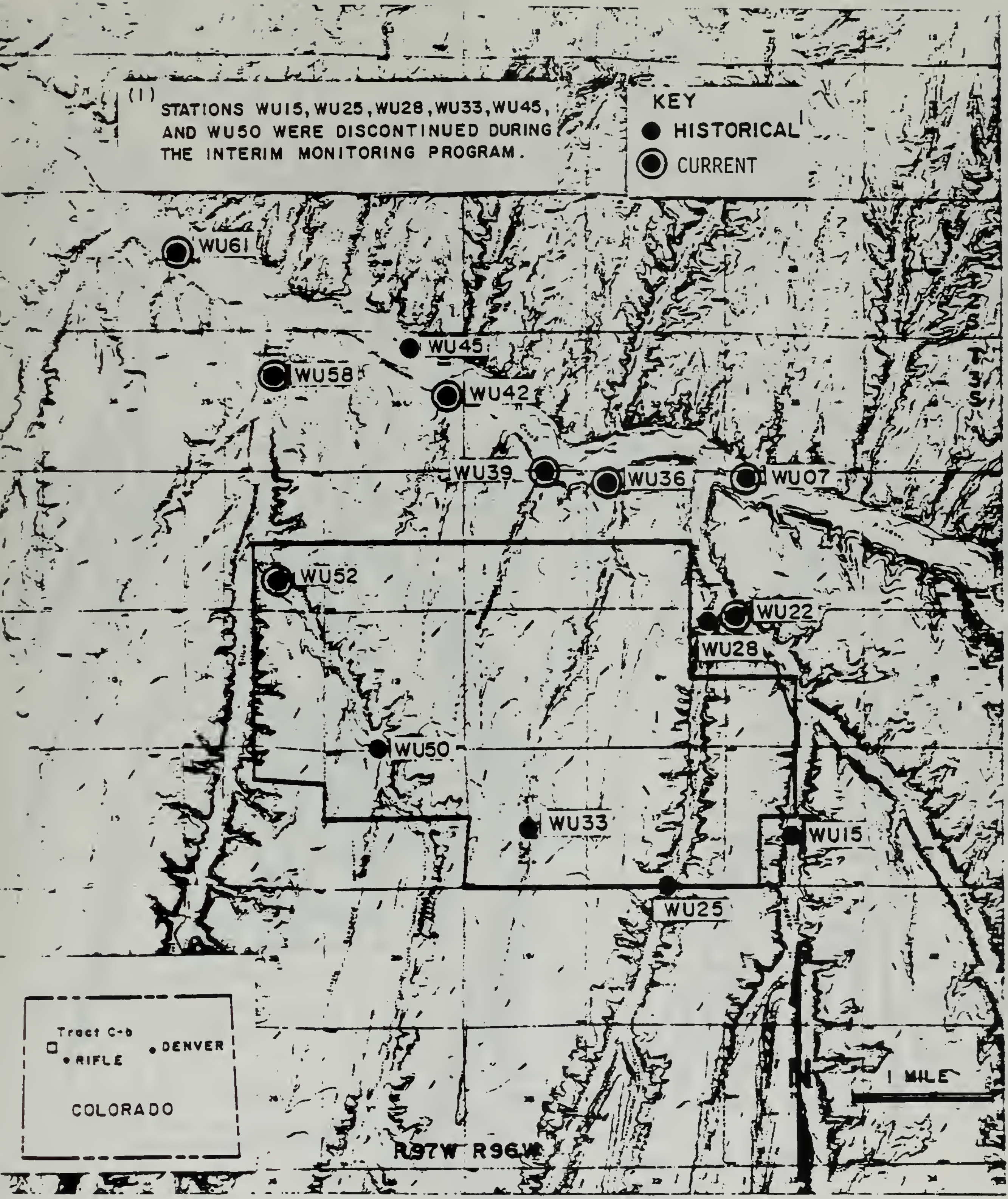


FIGURE 9-2 NEAR-TRACT STREAM GAUGING STATION MONITORING NETWORK

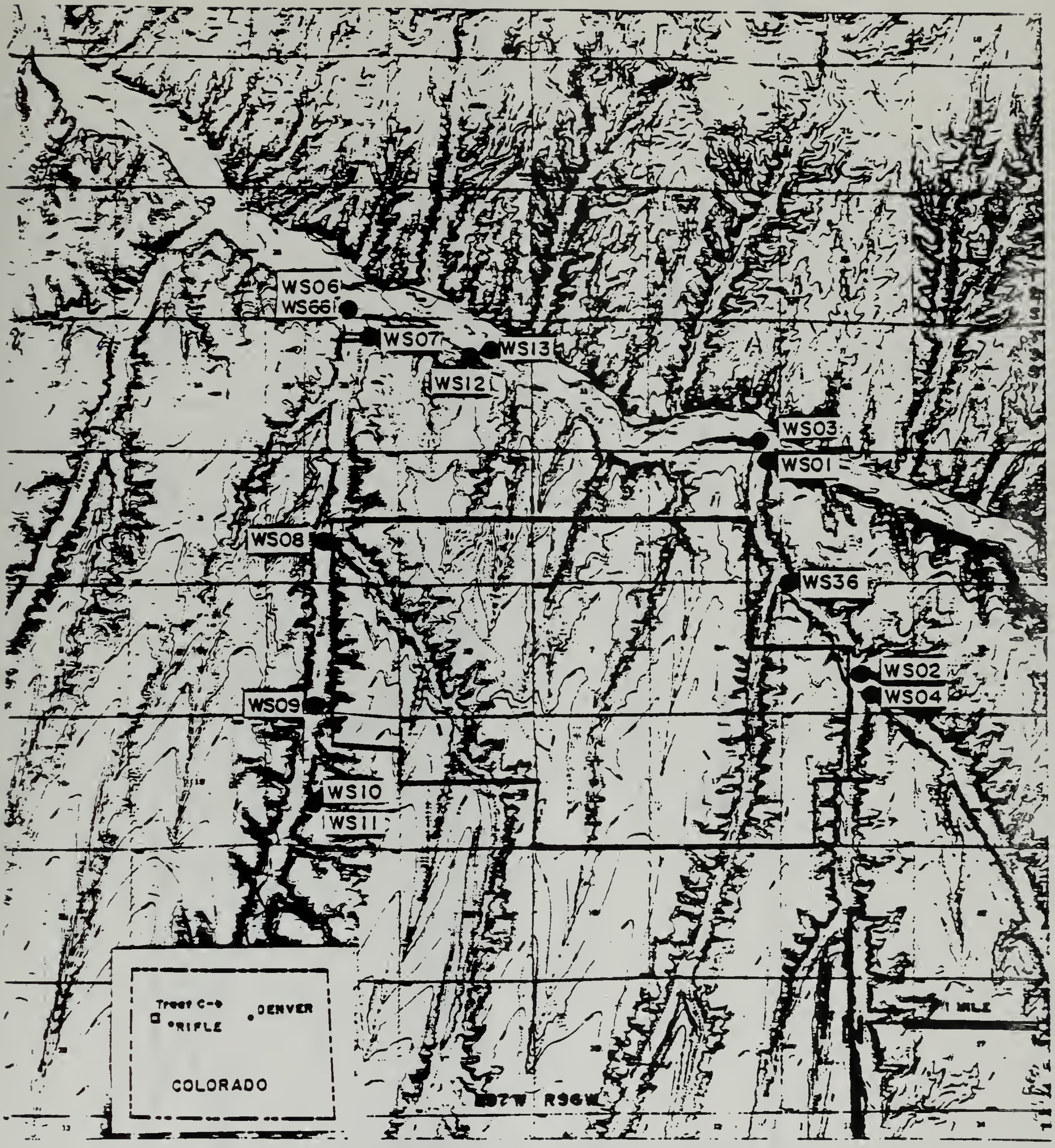
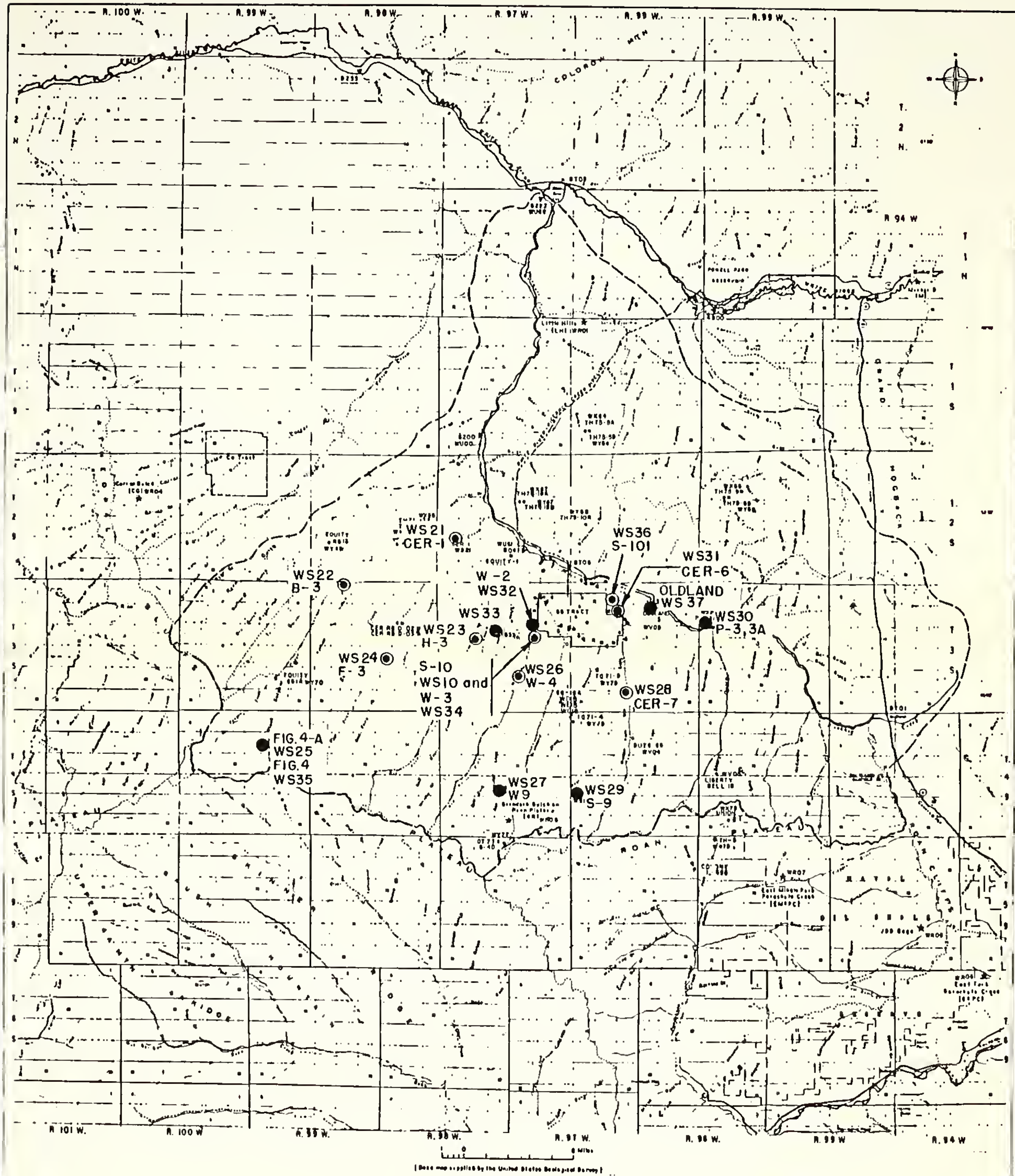


FIGURE 9-3a NEAR-TRACT SPRINGS AND SEEPS MONITORING NETWORK



KEY
- ● HISTORIC
- ◉ PROPOSED

FIGURE 9-3b

Springs and Seeps Monitoring Network Off-Tract

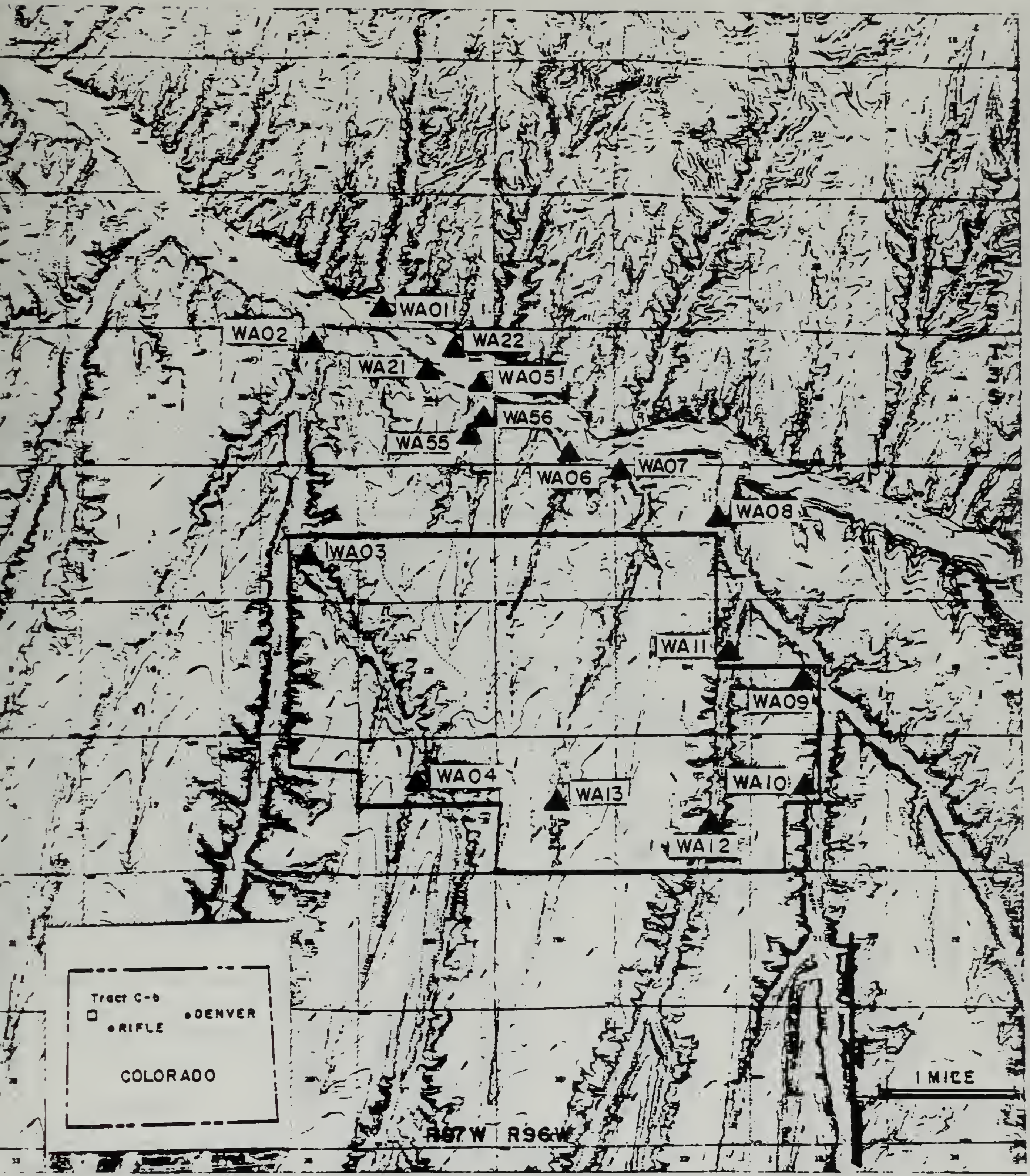


FIGURE 9-4 ALLUVIAL AQUIFER MONITORING NETWORK

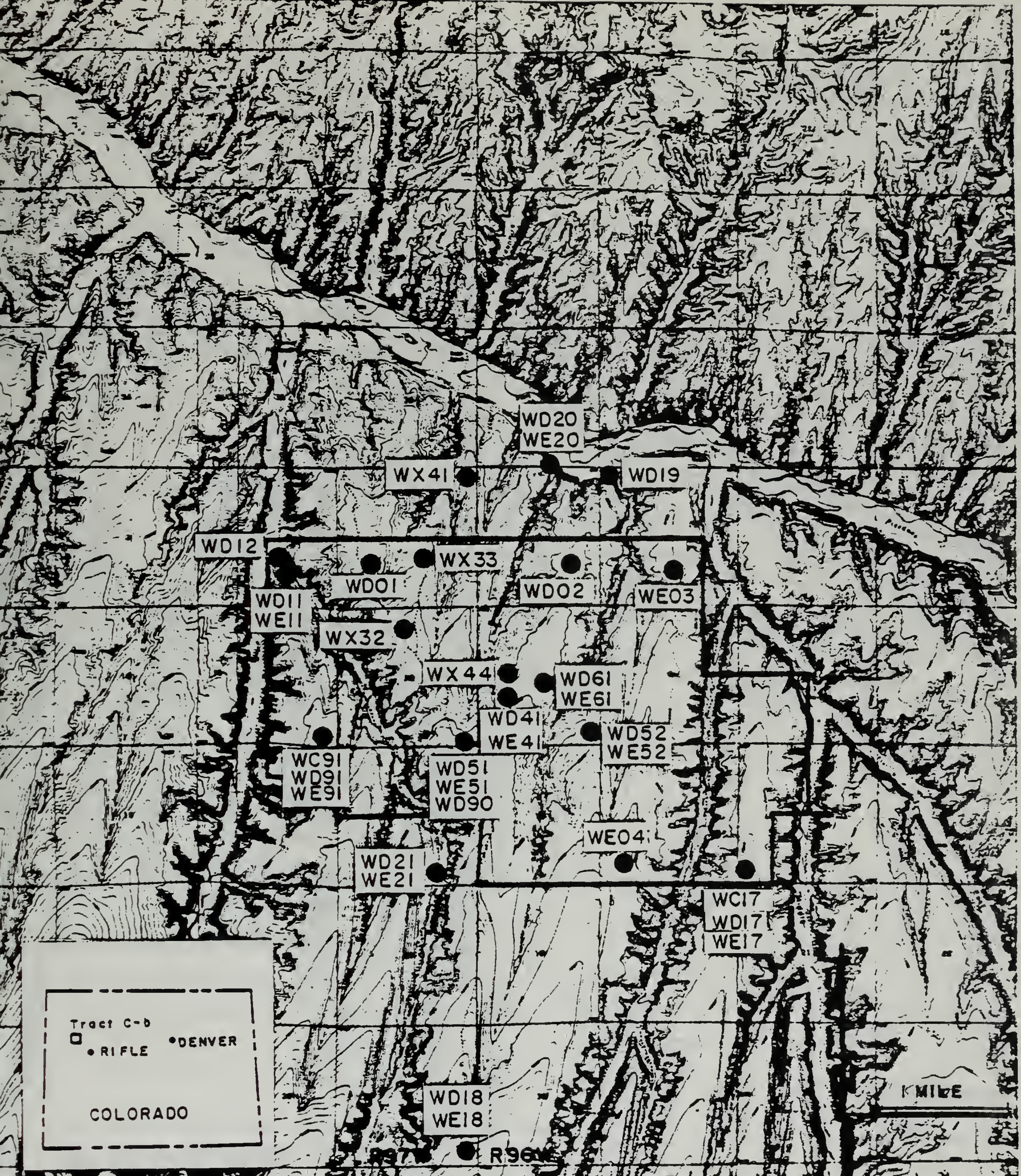


FIGURE 9-5a DEEP WELL MONITORING NETWORK NEAR C-b TRACT FOR UINTA, UPC_1 AND UPC_2 ZONES

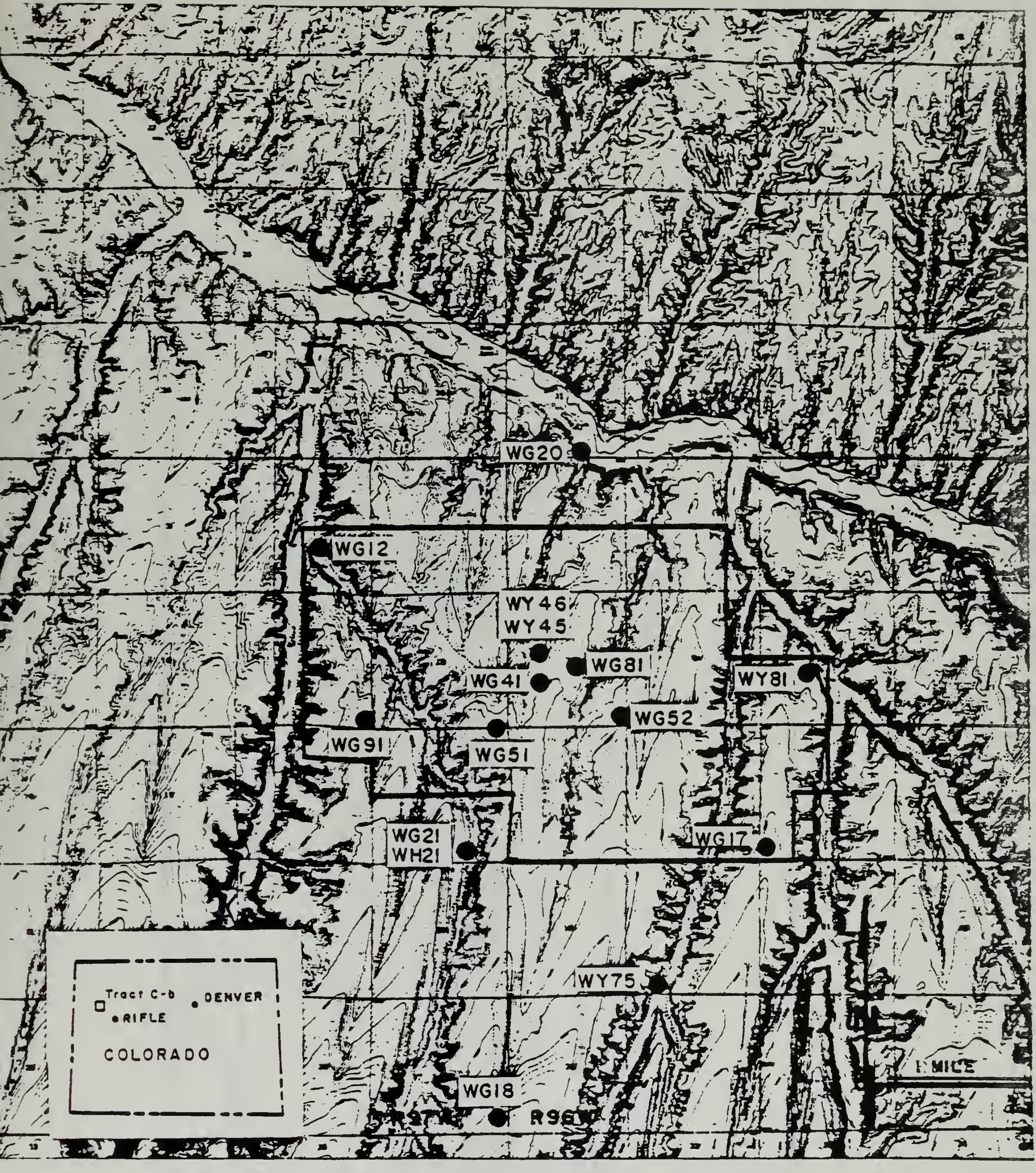


FIGURE 9-5b DEEP WELL MONITORING NETWORK NEAR C-b TRACT FOR LPC_3, LPC_4 ZONES

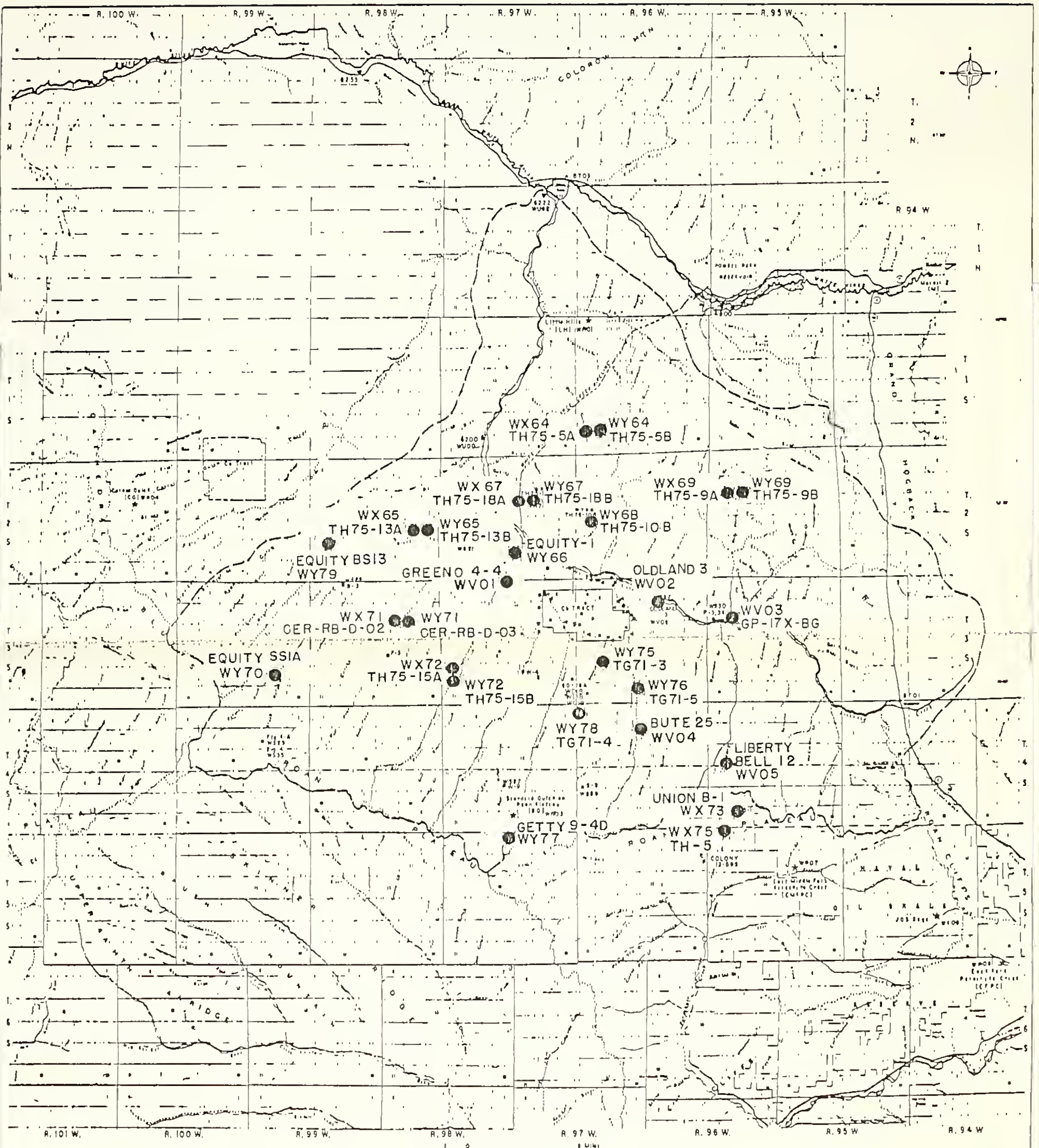
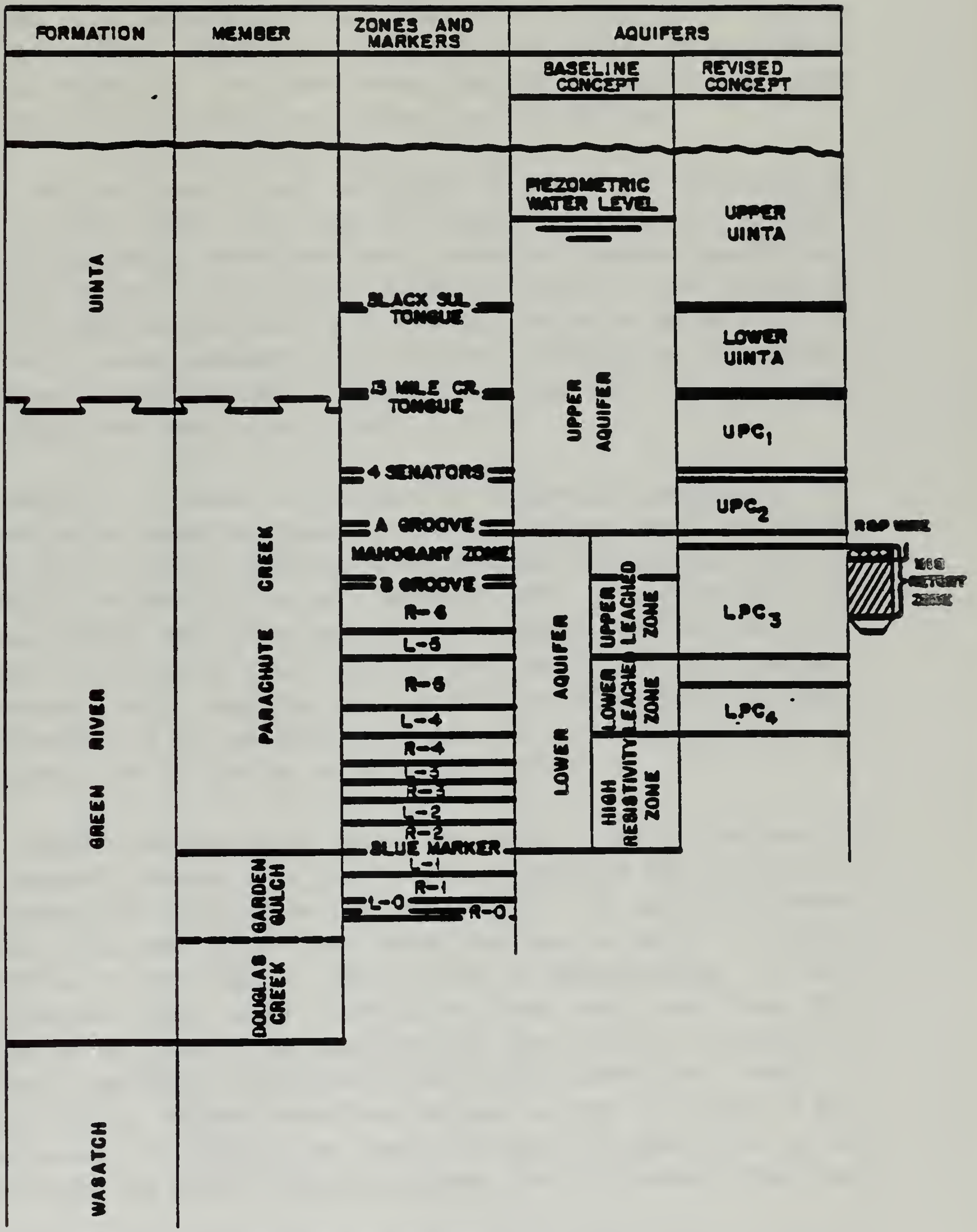


FIGURE 9-5c

DEEP WELL MONITORING NETWORK OFF-TRACT



STRATIGRAPHIC COLUMN AND
AQUIFER CONCEPT

FIGURE 9-6

The V/E shaft was allowed to fill in accord with approved plans in September 1981, as a temporary cost-saving device (i.e. reduction in cost of pumping for dewatering). Water level in this shaft has reached the equilibrium level shown on Figure 9-7. The level during baseline was approximately 6380 feet, approximately 70 feet above the current level of 6310 feet.

Over the past several years management of the excess waters due to dewatering of the shafts has been the major environmental activity. Historically, these excess waters have been disposed by temporary pond storage followed by discharge to 1) Piceance Creek via East No Name Gulch, 2) reinjection into deep aquifers and/or, 3) land application via sprinkling. See Figure 4-7 for the water management system layout. Although the only facility used in 1983 was surface storage - discharge, the other facilities which were used earlier have some time-residual effects.

In addition to routine monitoring, the hydrological program in 1983 addressed monitoring potential seepage from the holding ponds, monitoring stream flows and well levels to determine any potential effects resulting from shaft dewatering, monitoring alluvial - deep-well pairs to continue to verify lack of communication, monitoring the discharge under a newly obtained NPDES permit, acquisition of stream classifications for Piceance Creek and associated stream standards, initial planning for monitoring of unregulated pollutants under the guidelines of the Synthetic Fuels Corporation, and monitoring of the changed concentrations of fluoride in Spring S102 (WS12)*.

With regard to monitoring of stream flow, nine of the 18 stations are located on ephemeral streams. The other nine are considered major stations on perennial streams and record stream flow continuously. The monitoring network is conceptually the same as that used during the baseline period. Piceance Creek streamflow is summarized on Table 9-1 and on the hydrograph of Figure 9-8; the hydrograph also shows discharge of mine water from Ponds A/B. Baseline studies for 1975-76 indicated that the mean flow for the reach of Piceance Creek immediately downstream of the Tract (Station 6061 (WU61)) is approximately 17 CFS. Records since then indicate no major variations in mean annual flow except for 1983 (a wet year) for which the mean flow at the downstream station was 60 CFS. One-day minimum flows in Piceance Creek have

* In this section the "popular" station designation is given first followed by the computer code in parenthesis. Figures 9-2 to 9-5 show only computer code. Table 3.2-1 of the January 1984 Data Report cross references both designations.

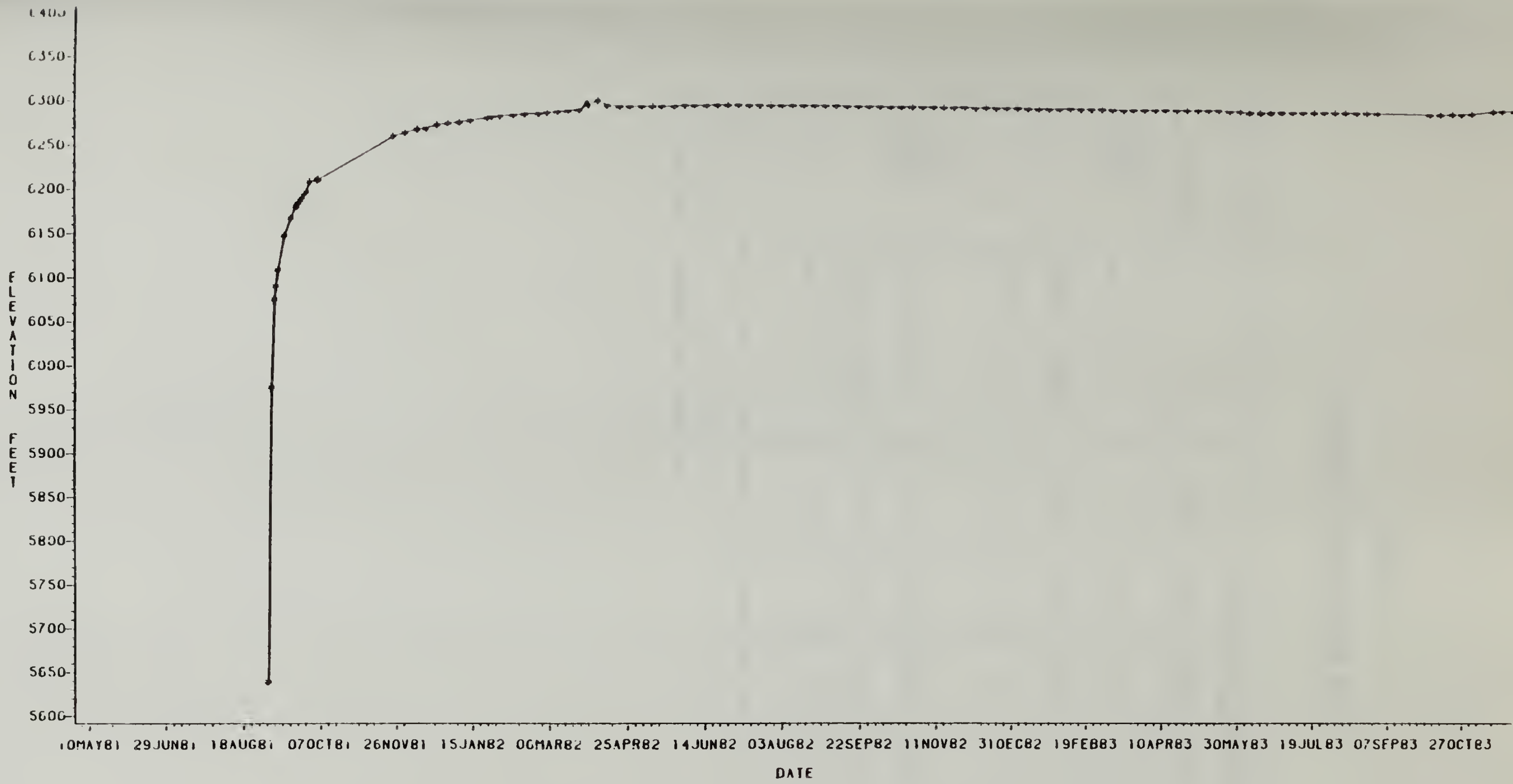


Figure 9-7

V/E Shaft Water Level vs Time

(Collar Elev.=6705 ft.)

TABLE 9-1

Piceance Creek Stream Flow

		Flow (cfs) for Water Year					
Station		1978	1979	1980	1981	1982	1983
6007 (WU07)	Max. Daily	83.0	158.0	135.0	18.0	29.0	365.0
	Monthly Mean	9.7	20.8	20.0	7.2	8.0	47.0
	Min. Daily	.60	2.0	5.1	0.5	1.3	5.2
6061 (WU61)	Max. Daily	52.0	149.0	133.0	34.0	37.0	430.0*
	Monthly Mean	10.9	24.6	25.6	12.9	11.4	60.0*
	Min. Daily	0.0	.63	4.6	0.5	2.9	8.9*

* See text, tentative results

[illegible]

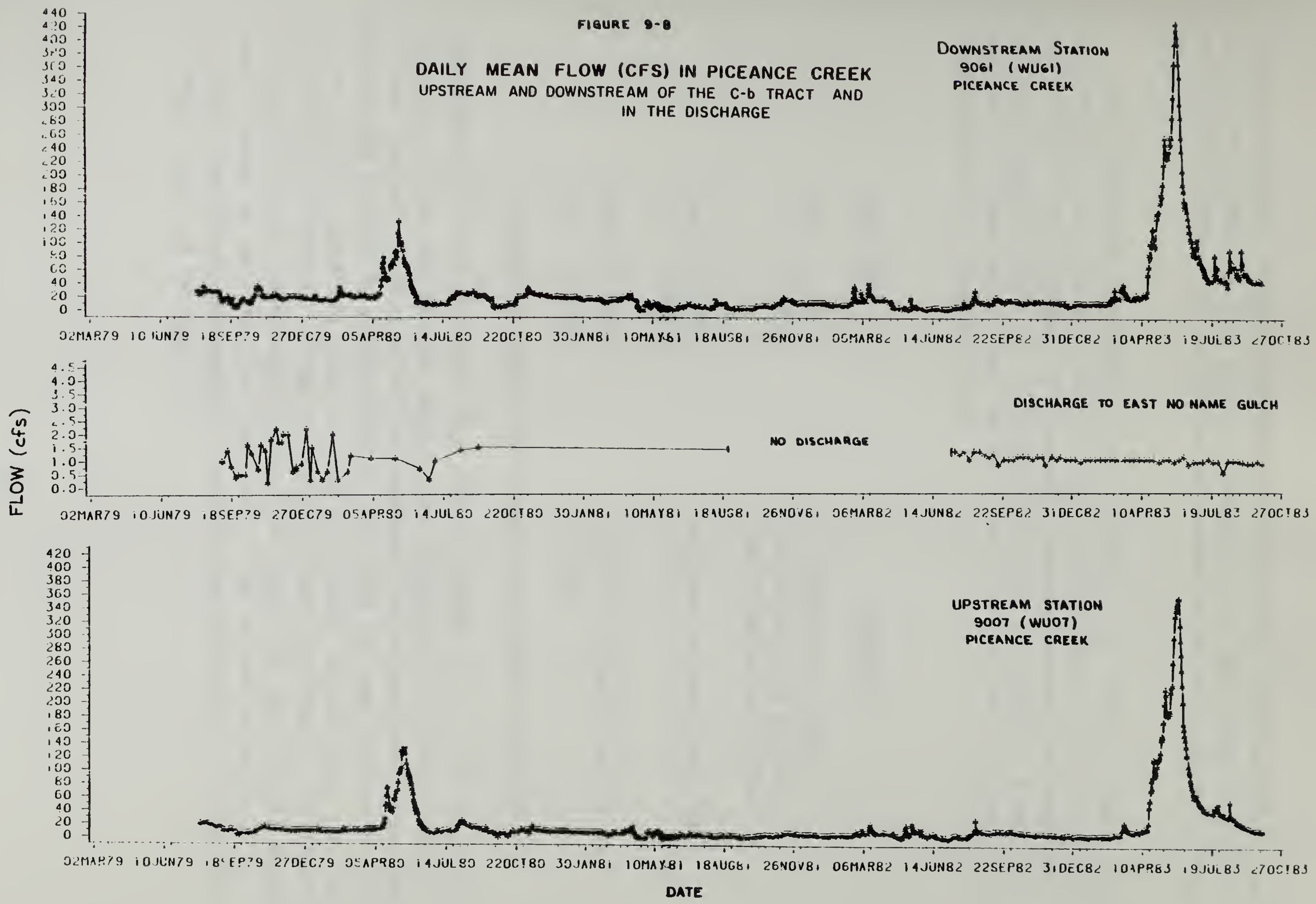
[illegible]

[illegible]

[illegible]

FIGURE 9-8

DAILY MEAN FLOW (CFS) IN PICEANCE CREEK
UPSTREAM AND DOWNSTREAM OF THE C-b TRACT AND IN THE DISCHARGE



reached zero flow. In 1983 the minimum daily flow at the downstream station was 8.9 CFS; the maximum was 430; values at Station 6061 for the current water year are tentative inasmuch as the station was washed out on May 7 due to spring floods.

With regard to groundwater, data collected over the past four years continue to strongly suggest that the tight confining zones of oil shale highly restrict the vertical movement of groundwater between the major hydrologic units. The most significant data in this regard come from well pairs. A well pair consists of a deep bedrock well and an alluvial well within close proximity. Three such well pairs are as follows:

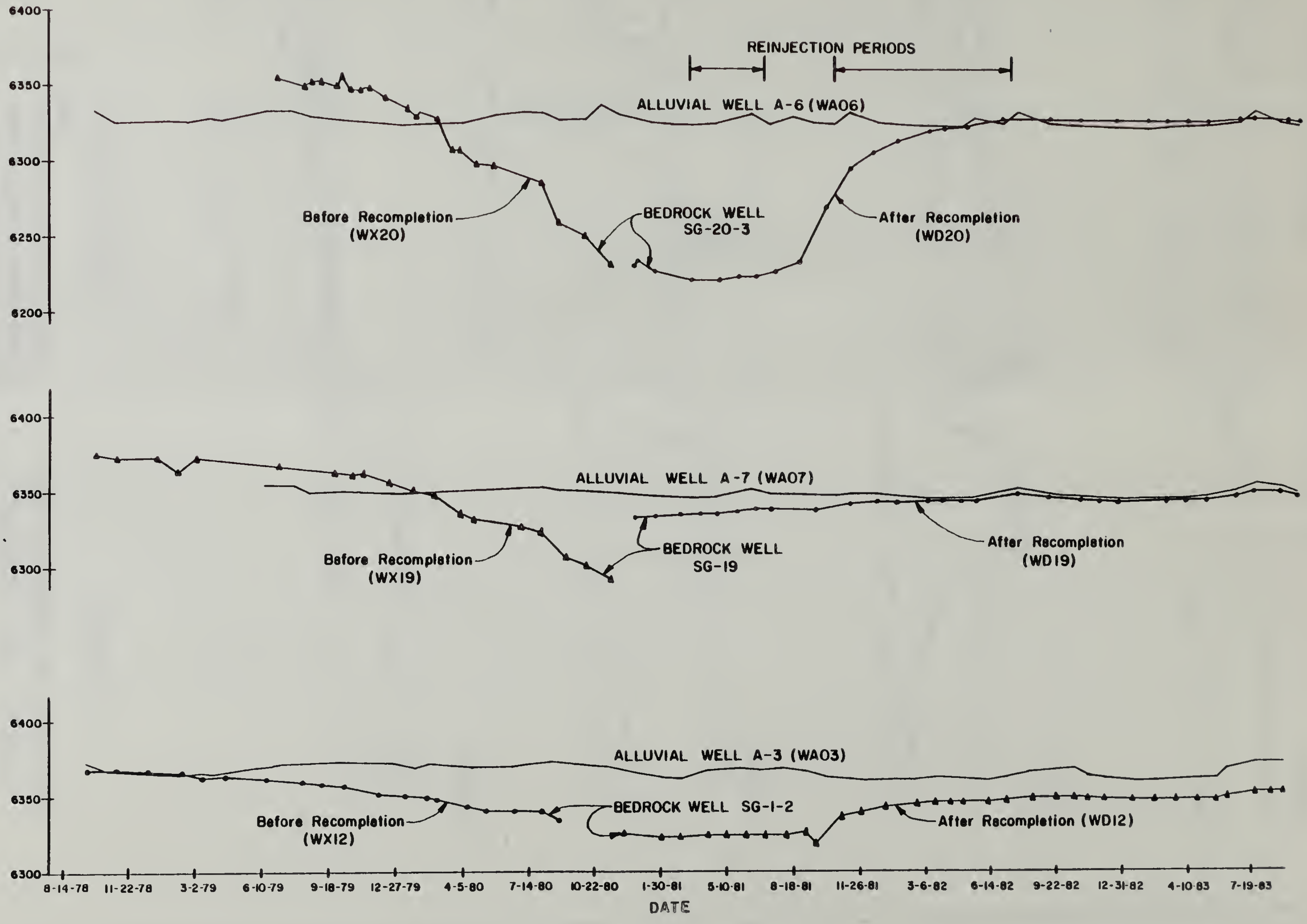
Well Pair	Location
SG-1-2 (WD12), A-3 (WA03)	In Scandard Gulch near its intersection with Willow Creek in NW corner of Tract
SG-19 (WD19)*, A-7 (WA07)	Adjoining Piceance Creek, North of Tract
SG-20-3 (WD20) A-6 (WA06)	Adjoining Piceance Creek, North of Tract

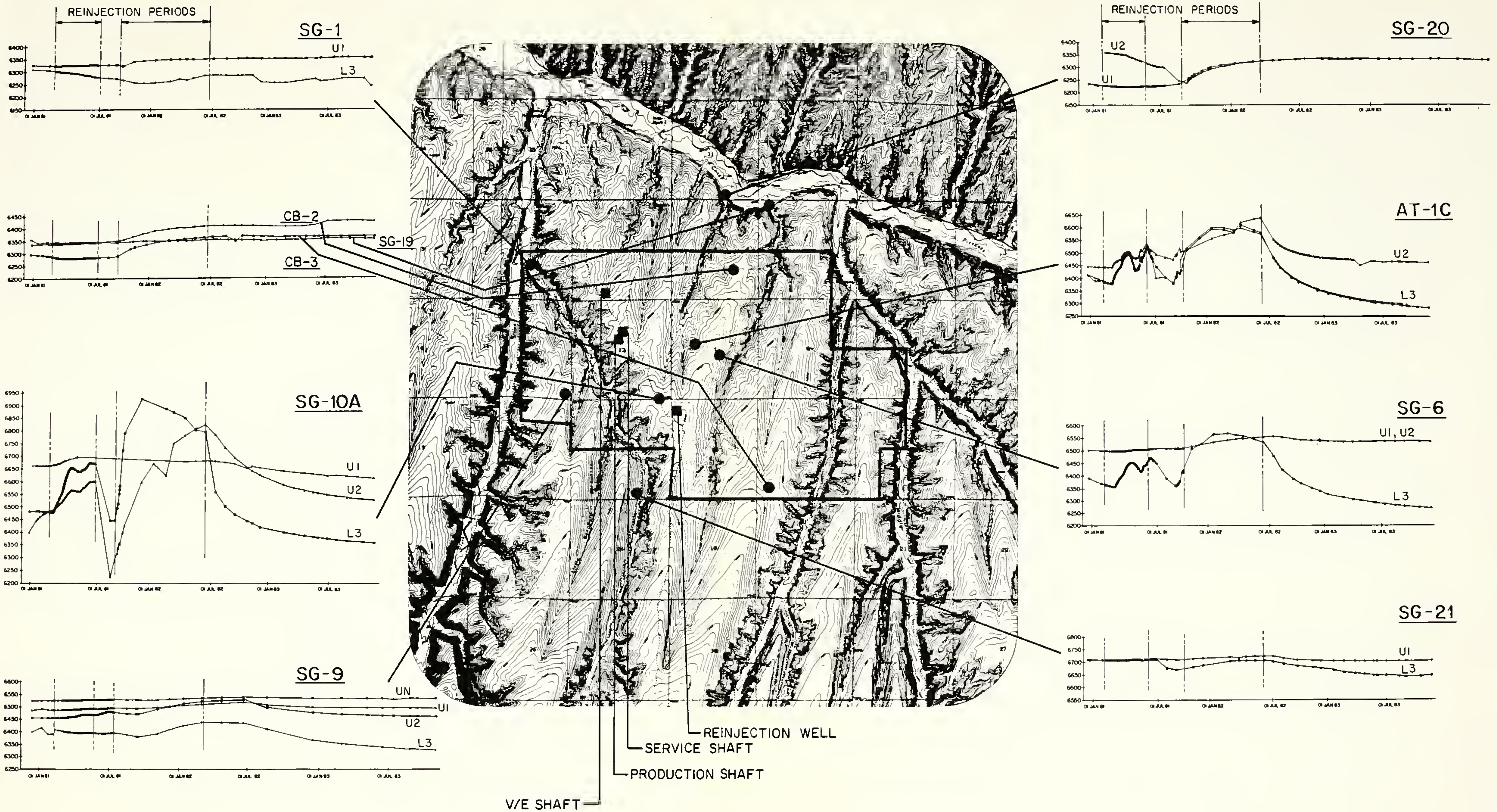
* Adequacy of bedrock well completion is under investigation.

Interpretation of the well-pair data indicate whether or not the dewatering activities in the deep bedrock aquifers are affecting the alluvial aquifers. As shown typically in Figure 9-9, the depressurizing effects which have been detected and measured in the deep bedrock wells have not been observed to date in the alluvial companions, thus we have no evidence to date that they are hydrologically connected. Periods of reinjection are also shown on the figure. Additionally lack of communication between the Uinta (UN) Zone and the deeper zones is shown for well SG-9 on Figure 9-10. The UN zone is portrayed by a horizontal time history independent of the these decreasing-level time-histories for zones below it in the same well.

COMPARISION OF WATER LEVELS IN C-B WELL PAIRS

Figure 9-9





• WELL STRING KEY •

UN UINTA
U1 UPPER PARACHUTE CREEK ZONE 1
U2 UPPER PARACHUTE CREEK ZONE 2
L3 LOWER PARACHUTE CREEK ZONE 3

FIGURE 9-10

TIME HISTORIES OF SELECTED BEDROCK WELL LEVELS

Time histories of 10 selected bedrock well levels, most of which possess multiple strings in zones:

UN = Uinta Zone
U1 (UPC_1) = Upper Parachute Creek Zone 1
U2 (UPC_2) = Upper Parachute Creek Zone 2
L3 (LPC_3) = Lower Parachute Creek Zone 3,

are shown on Figure 9-10 and identified as to location. Note the periods of reinjection from March 2 to June 20, 1981 and from October 8, 1981 to June 30, 1982; the reinjection well is located very near Well SG-10A and is shown on Figure 4-7. The large sinusoidal oscillations in well levels are due to effects of reinjection and are most pronounced for wells close to the reinjection site.

Potentiometric surfaces are shown on Figures 9-11a to 9-11c for the dates of September 1981, April 1982, and August 1983. These dates are, respectively: 3 months after termination of the first reinjection period, during the second reinjection period, and 1 (plus) year after termination of the second reinjection period. The contours are approximately similar. The low point is centered at the Production/Service Shafts (@ 5064 feet elevation); levels at the V/E Shaft (3700 feet distant from the Production Shaft) agree with Figure 9-7 and show levels increasing from 6182 feet elevation (September 1981) when it initially was allowed to start flooding to 6310 feet elevation at present (a rise of 228 feet). Levels at the reinjection well approximately 4000 feet distant from the Production/Service mine shafts have changed from 6581 feet elevation (September 1981) to 6419 feet elevation as of December 1981. The injection well has been inactive since July 1982.

Further insights into the nature of groundwater flow beneath the C-b Tract have been obtained from downhole temperature logging of 16 wells*. For example, zones with low or reversed water temperature gradients (with depth) normally indicate active groundwater movement. Zones with a high temperature

---

* Hutchison, W. R. and G. T. Pavlov. (1983): Interpretation and Conclusions from Downhole Temperature Logs of Selected Wells. Tract C-b, Piceance Basin, Colorado. Geothermal Surveys Inc., 1 September 1983. (Entire document included in January 15, 1984 C-b Data Report to the Oil Shale Project Office)

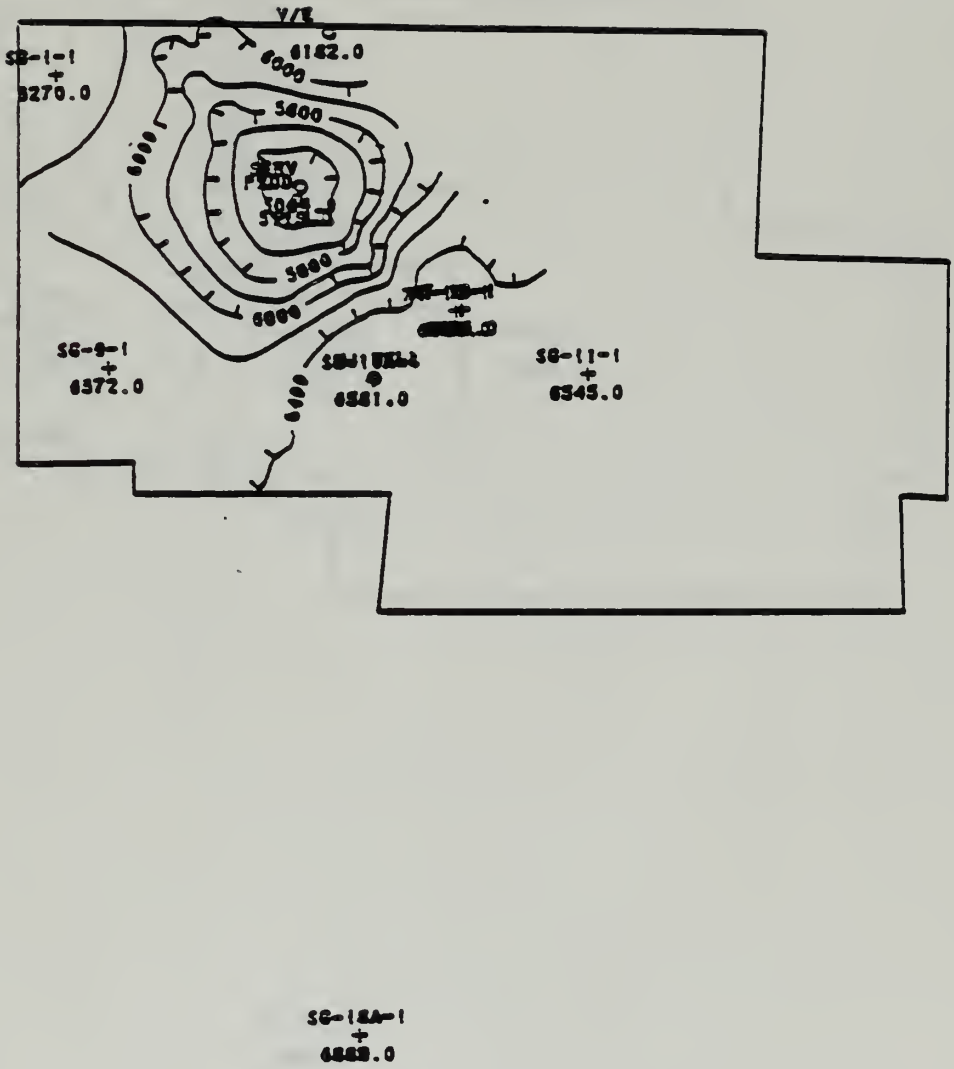


Figure 9-11a

POTENTIOMETRIC SURFACE MAP FOR SEPT. 15, 1981
LPC_3, B WELLS CNTR INT = 200.0'

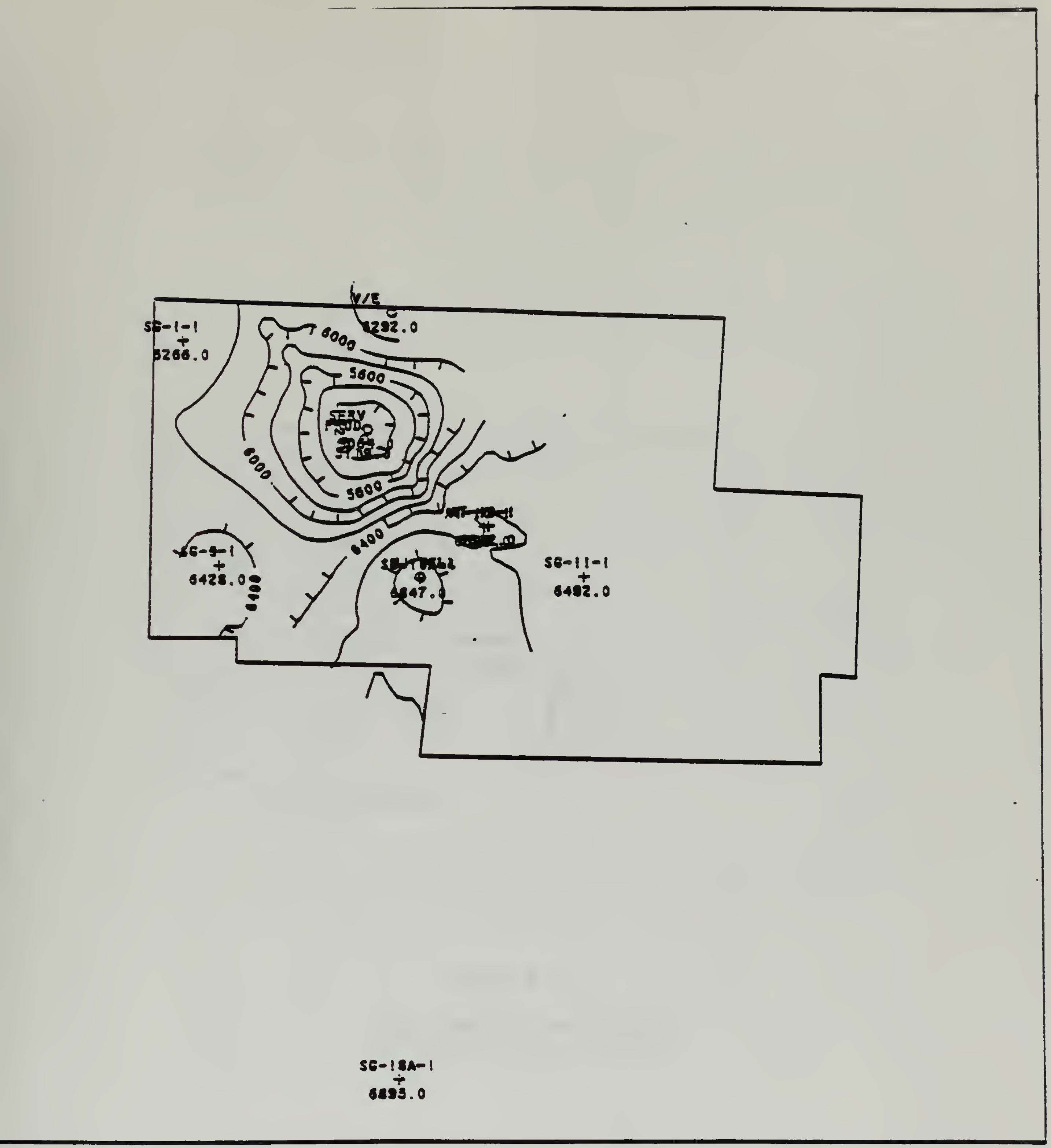


Figure 9-11b

POTENTIOMETRIC SURFACE MAP FOR APRIL 16, 1982
LPC_3, B WELLS CNTR INT = 200.0'

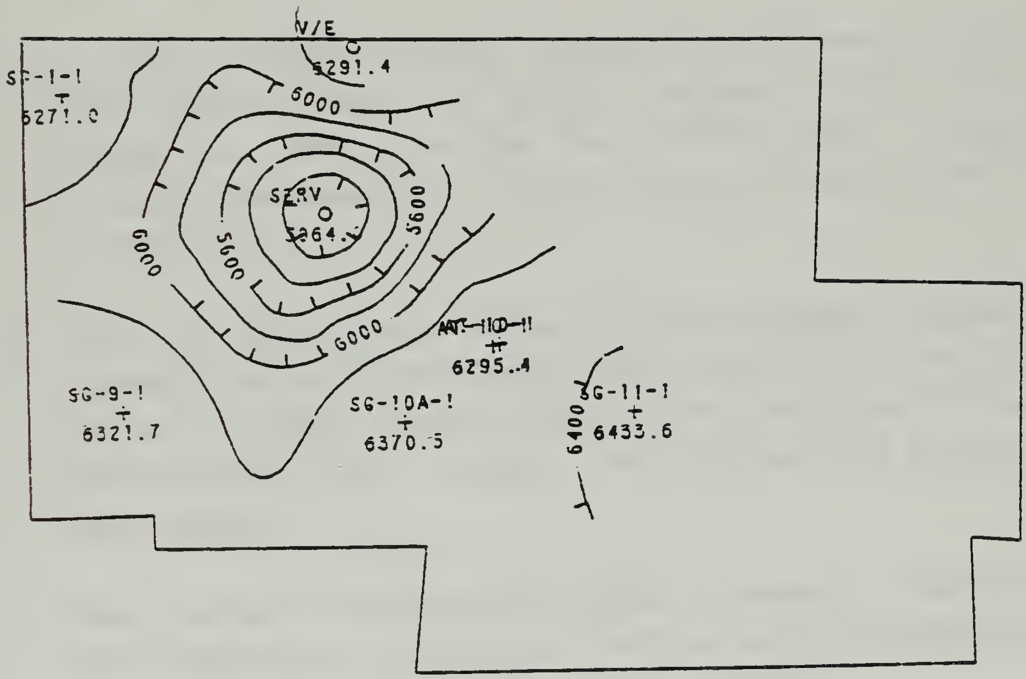


Figure 9-11c

Potentiometric Surface Map
for Aug. 83, LPC_3, B Wells

SG-18A-1
6841.8

gradient normally indicate little or no groundwater movement. Vertical flow across strata is usually indicated by zero gradient. Conclusions from the cited reference of this complex geohydrological picture are still subject to further refinements and interpretation and are as follows:

1. The Four Senators act as a barrier to upward flow. This conclusion is drawn from the profiles in Wells 32X12, 33X1, SG10A, SG11, 22X17, and 24X17.

2. The Uinta Formation is a better aquifer than the underlying Parachute Creek Formation except for specific horizons -- such as the zone between the A-Groove and the Four Senators zone -- within the Parachute Creek Formation. This conclusion is drawn from Wells 33X1, Cb-2 and SG-1.

3. There has been no major effect in the northeast, northwest and southwest portions of the Tract by the dewatering of the S/P Shafts and the reflooding of the V/E Shaft. This conclusion is drawn from Wells Cb-3, SG-1, SG-6 and SG-9. Wells SG-1 and SG-9 are down 50-70 feet, however.

4. There has been a depressurizing effect southeast of the S/P Shafts due to dewatering of the shafts. This conclusion is drawn from Wells SG-6, AT-1D, SG10A, 14X7, SG-11, 22X17, and 24X17.

5. The Black Sulfur Tongue appears to act as an aquitard isolating the upper Uinta from deep aquifers. This conclusion is drawn from Wells 21X12 and 14X7, and appears to support the conclusions reached recently by Beard (1983, unpublished).

6. The effect of the 1981 reinjection test is evident in the southeastern part of the Tract. Conditions appear to be returning to pre-test conditions as evidenced by the warming trend in an aquifer between the Four Senators and A-Grove. This preliminary conclusion is drawn from Wells 22X17 and 24X17 and is subject to further study.

Water quality data for stations upstream (Station 9007 (WU07)) and downstream (Station 9061 (WU61)) from the Tract on Piceance Creek, and for stations in Stewart and Scandard Gulches are summarized on Table 9-2a by comparison with baseline. Table 9-2b is a supporting table for Table 9-2a in that mean values and 95% confidence intervals are shown for three cases: 1983 only, for 1974-83 and for 1974-82. Based on these data the confidence intervals are quite satisfactory. Ratios of twelve-month means for WU61 and WU07 are shown on Table 9-3.

During 1983, discharges to East No Name Gulch were made during the year under the NPDES permit, and Station 9042 (WU42) measured water quality affected by these discharges. All discharges in 1983 contained fluoride levels characteristic of the lower aquifer zones; when diluted with Piceance Creek waters the fluoride maximum value was 0.9 mg/l. On an annual average, fluoride which increased (@ Station WU61) from 0.8 to 2.2 mg/l in 1981 is now back to 1. Time series plots of fluoride and specific conductance at the up- and down-stream stations in Piceance Creek and in the discharge are presented on Figure 9-12a and b, respectively. Refer to Section 7.2 for further discussion on permit compliance.

The holding pond (Pond A/B) was checked for seepage by comparing key water quality parameters with those of its downdip seepage monitoring well. Current mine water pumped to the ponds comes primarily from the lower aquifer (LPC_3) and has elevated levels of sodium and fluoride. Water in the seepage monitored from the upper aquifer (UPC_1) is of high calcium, low fluoride. Table 9-4 shows that these upper aquifer characteristics have been preserved.

For springs and alluvial and deep wells there are no significant long-term trends in water quality values for any of the major constitutents. Variables examined for trends were temperature, pH, conductivity, DOC, arsenic, fluoride, boron, TDS, molybdenum, sodium, sulfate, and ammonia. Spring S102 is the one exception. Its fluoride level has increased to levels of 7-8 mg/l in 1983 from values typical of all other springs (0.5-1) in 1980 as shown in Figure 9-13. This spring is downstream of the East No Name Gulch discharge point. Continuing analysis will be undertaken to determine the source of this spring.

TABLE 9-2a

Comparisons of 1983 Water Year vs. Baseline
for Mean Values of Major Water Quality Constituents
Values are in mg/l

	WU07 (P.C. Upstream of Tract)		WU22 (Stewart Gulch)		WU58 (Willow Creek)		WU61 (P.C. Downstream of Tract)	
	1982-1983	Baseline	1982-1983	Baseline	1982-1983	Baseline	1982-1983	Baseline
NH_3	0.14	0.04	0.09	0.02	0.10	0.02	0.15	0.03
As	0.0025	0.0024	0.0012	0.0010	0.0012	0.0011	0.0022	0.0023
B	0.156	0.209	0.083	0.108	0.119	0.210	0.144	0.214
Ca	67	69	87	93	90	92	66	78
Cl	14	15	6.6	7.2	12.0	11.5	13	14
F	0.6	0.9	0.3	0.3	0.4	0.4	0.7	0.9
Mg	41	46	71	76	71	76	47	67
Mn	0.049	0.046	0.05	0.010	0.021	0.014	0.042	0.066
K	3.1	3.6	1.5	1.6	2.2	2.2	3.1	3.5
Si	14	15	20	15	15	15	15	17
Na	99	122	105	124	100	128	109	150
TDS	673	692	916	936	836	926	826	902
SO_4	163	164	352	368	320	356	201	290

Station values in 1982-1983 are for the months of 9/82 to 9/83 (i.e. WY 1983) from USGS water data.
Baseline values are for the period 11/74 to 10/76 - from environmental baseline program.

TABLE 9-2b

Mean Values and 95% Confidence Intervals
Water Years 1974-1983

WQ Parameters	STATION 9007 (WU07) mg/l			STATION 9061 (WU61) mg/l		
	1983 only	1974 - 1983	1974 - 1982	1983 only	1974 - 1983	1974 - 1982
NH_3	0.14 ± 0.09	0.14 ± 0.05	0.15 ± 0.06	0.15 ± 0.14	0.13 ± 0.08	0.11 ± 0.04
As	0.0025 ± 0.0007	0.0025 ± 0.0004	0.0024 ± 0.0004	0.0022 ± 0.0006	0.0024 ± 0.0004	0.0026 ± 0.0004
B	0.156 ± 0.034	0.181 ± 0.023	0.209 ± 0.011	0.144 ± 0.031	0.176 ± 0.026	0.212 ± 0.022
Ca	67 ± 5	69 ± 3	70 ± 4	66 ± 0	70 ± 6	75 ± 4
Cl	14 ± 1.9	14 ± 1.3	13 ± 1.8	13 + 2.1	13 ± 1.4	13 ± 1.8
F	0.6 ± 0.2	0.7 ± 0.1	0.9 ± 0.2	0.7 ± 0.3	0.8 ± 0.2	0.9 ± 0.3
Mg	41 ± 4	44 ± 3	47 ± 3	47 ± 9	56 ± 7	66 ± 6
Mn	.049 ± .019	0.083 ± 0.033	0.113 ± 0.051	.042 ± .033	0.073 ± 0.033	0.099 ± 0.047
K	3.1 ± 1.1	3.0 ± 0.6	2.9 ± 0.6	3.1 ± 1.1	2.9 ± 0.7	2.8 ± 0.9
Si	14 ± 1.3	1.5 ± 0.9	15.7 ± 0.7	15 ± 1.2	16 ± 0.9	16.6 ± 0.7
Na	99 ± 18	112 ± 13	127 ± 13	109 ± 24	132 ± 20	159 ± 19
TDS	673 ± 46	695 ± 42	705 ± 57	826 ± 31	899 ± 80	920 ± 99
SO_4	163 ± 27	168 ± 16	173 ± 15	201 ± 45	244 ± 38	293 ± 38

TABLE 9-3

Downstream-to-Upstream* Ratios
of 12-Month Means, October 1-October 1**

	Baseline	1980-1981	1981-1982	1982-1983
Alk	1.10	1.17	1.09	-
NH_3	0.75	1.43	1.00	1.07
As	0.96	1.03	1.13	0.88
B	1.02	1.12	1.02	0.92
Ca	1.13	0.95	1.07	0.99
Cl	0.93	0.71	1.00	0.93
F	1.00	2.23	1.44	1.17
Mg	1.46	1.26	1.41	1.16
Mn	1.43	0.47	0.79	0.86
K	0.97	1.05	0.97	1.00
Si	1.13	1.20	1.06	1.07
Na	1.23	1.43	1.23	1.11
SO_4	1.77	1.61	1.30	1.23
TDS	1.30	1.28	1.72	1.23

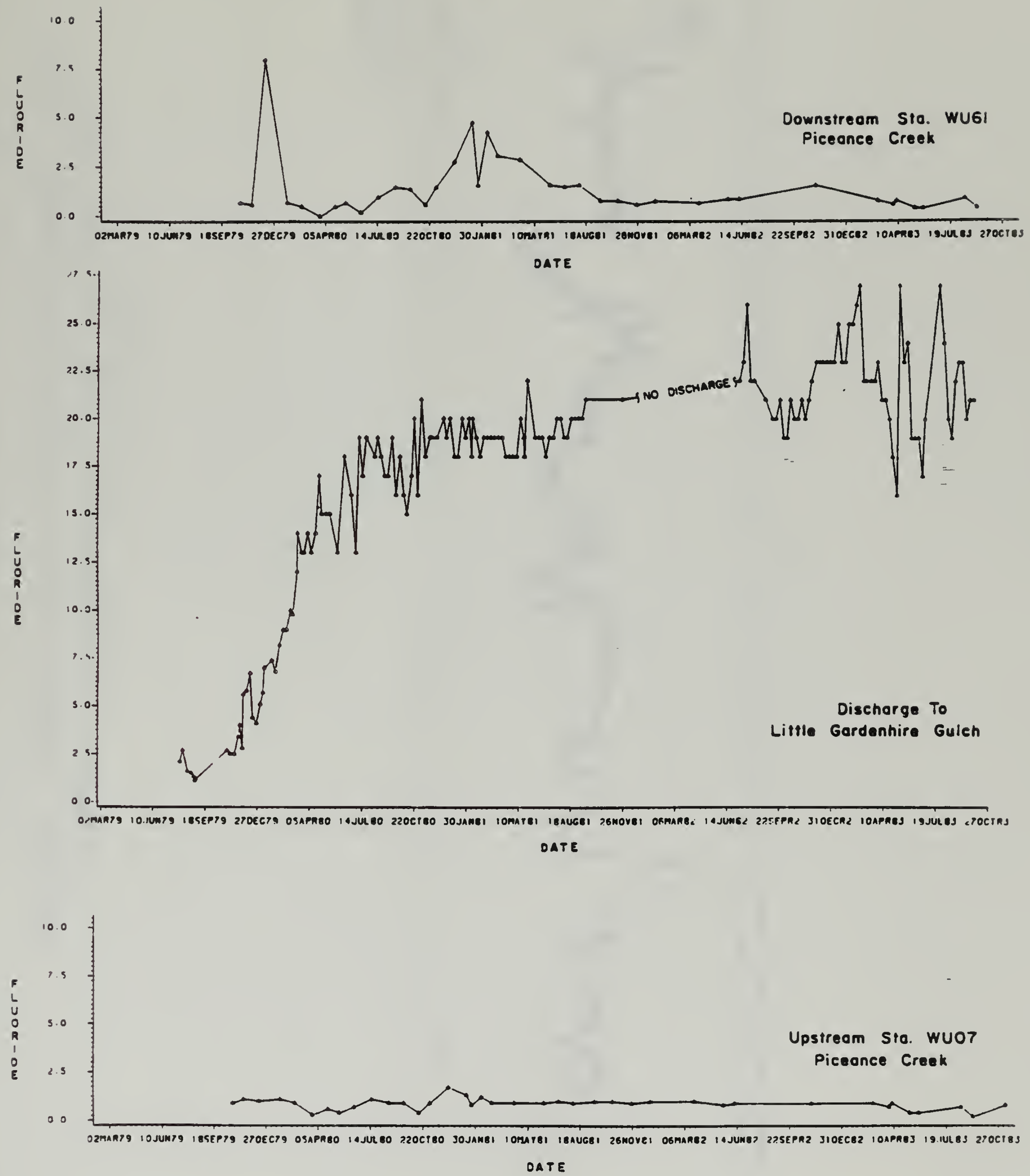
*Station WU61 is on Piceance Creek, downstream of the Tract;
Station WU07 is on Piceance Creek, upstream of the Tract.

**No discharge occurred from October 1981 thru June 1982

The tabular values are the ratio of $\frac{\text{WU61}}{\text{WU07}}$

FIGURE 9-12a

FLUORIDE CONCENTRATIONS (MG/L) IN PICEANCE CREEK
UPSTREAM AND DOWNSTREAM OF THE C-b TRACT AND
IN THE DISCHARGE



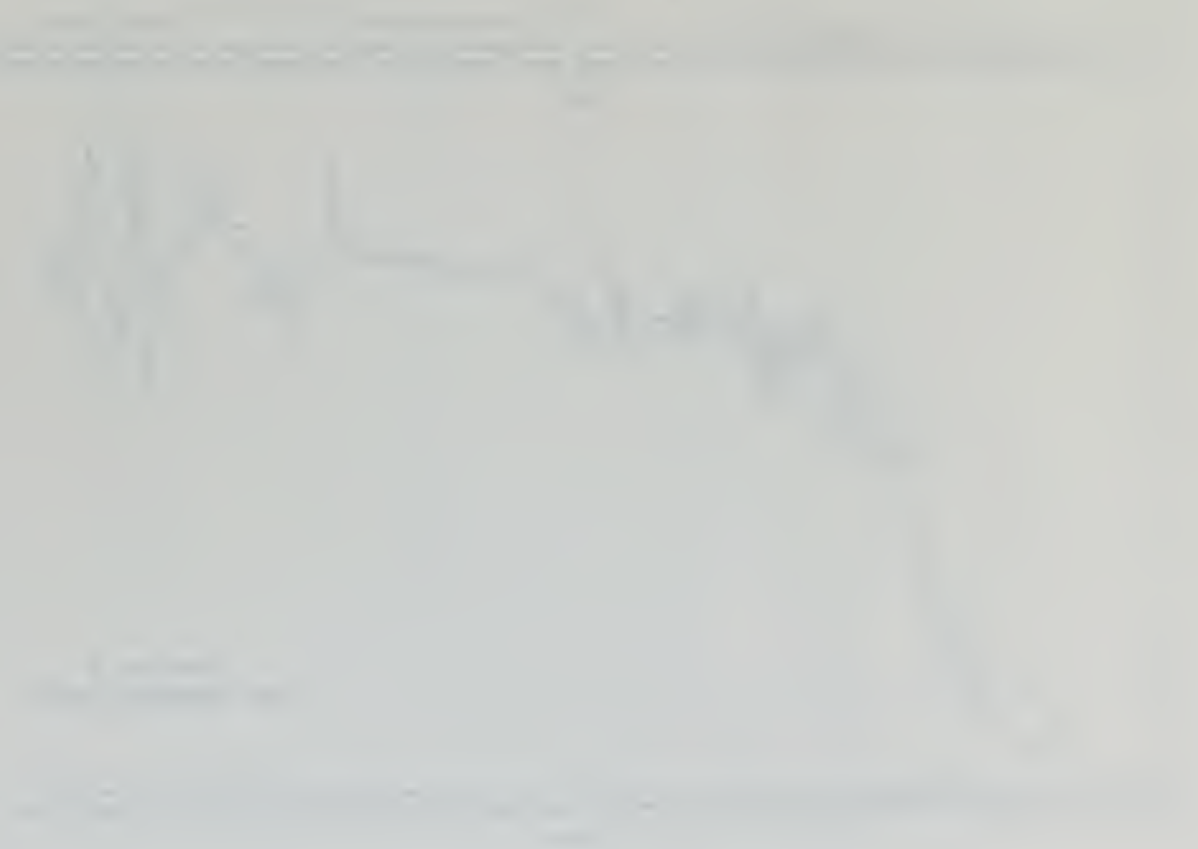


Figure 9-12b

SPECIFIC CONDUCTANCE (UMHOS) IN PICEANCE CREEK
UPSTREAM AND DOWNSTREAM OF THE C-b TRACT AND
IN THE DISCHARGE

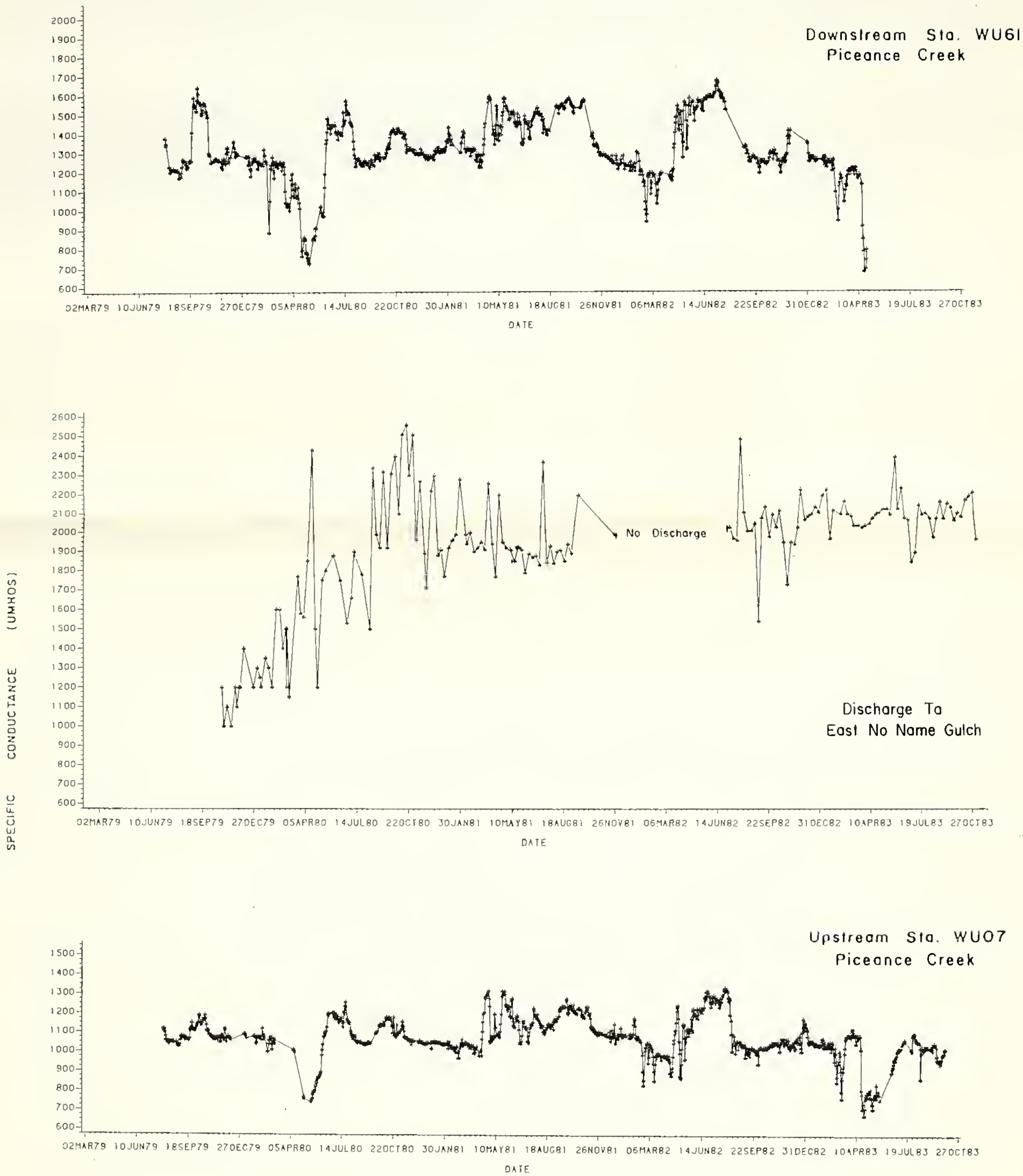


TABLE 9-4

Comparison of Pond A/B (WN40) with its Seepage Monitoring Well (WW22)

Water Quality Parameter	Sampling Date	Value (mg/l)	
		Pond	Seepage Well
Na	Spring '81	-	170
	Spring '82	540	250
	Spring '83	610	260
F	Spring '81	19	1.5
	Spring '82	22	0.7
	Spring '83	21	0.3
Ca	Spring '81	-	98
	Spring '82	5.2	150
	Spring '83	7.1	230

9.3.4 Aquatic Biology

Benthos and periphyton sampling was conducted in 1983 as it has been since 1979. Sampling in May was not possible due to high stream flows so a November sample was added. A total of 39 benthic taxa were found at the three sampling stations; 31 at Stewart Station, while 23 occurred at Middle and Hunter Stations. Haplotaxida and Diptera tended to predominate throughout the year at all sites. Microinvertebrate density values for 1983 were generally significantly different from previous years, especially 1982. Grand mean density values (i.e., mean density all samples collected during the same months) were four times higher at Stewart Station, ten times higher at Middle Station and seven times higher at Hunter Station in 1982 than in 1983.

When 1983 macroinvertebrate densities were compared between sites and among months (Table 9-5), Hunter and Middle Stations had similar density values; Stewart and Middle Stations had less similarity; and Stewart and Hunter Stations had the least similarity.

Gray and Ward (1978) reported that benthic macroinvertebrate density, diversity, and biomass tended to decrease in downstream reaches of Piceance Creek which then was attributed, in part, to the withdrawal of irrigation water and the inflow of groundwater and spring-fed tributaries. This same pattern of lower density values at downstream locations recurred in 1983; moreover, density values were sharply lower at all sites in 1983 than in 1982. The same groups of macroinvertebrates (Haplotaxida, Epehmeroptera, and Diptera) still tended to predominate, but in slightly different proportions. Therefore, it appears that some factor other than the development of the C-b Tract accounted for the differences observed among stations during 1983. Specifically, stream discharge was unusually high in March, April, and May (see Section 9.3.3) which would account for the depressed benthic density values in July. In addition, stream discharge doubled for a brief period in early August due to flooding and apparently caused significant siltation. Rubble formerly present at all three stations was replaced by sand and small gravel. Haplotaxida and

Figure 9-13

TIME SERIES PLOT
OF FLUORIDE FOR SPRING S-102 (WS12)

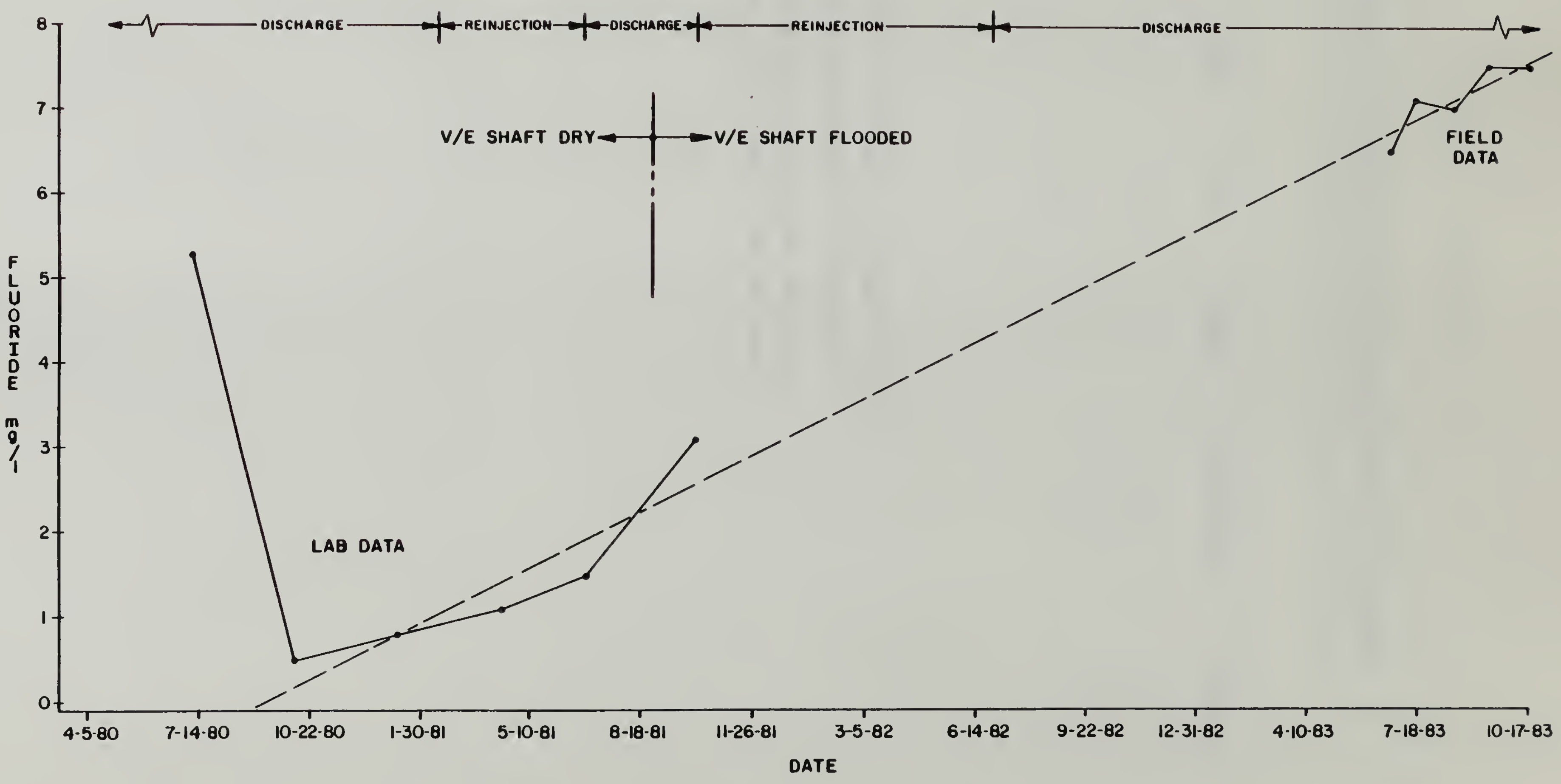


TABLE 9-5

Comparison of Benthic Macroinvertebrate Densities Between Sampling Stations During 1983 Using Fisher's LSD Procedure 1/

COMPARISON	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
Stewart-Middle	--	5%	--	5%	--
Stewart-Hunter	--	--	--	1%	2%
Hunter-Middle	--	5%	--	--	--

1/ -- = No significant difference between stations
5% = Difference significant at the 5% level
2% = Difference significant at the 2% level
1% = Difference significant at the 1% level

and Diptera, especially Chironomidae and Tipulidae, tend to favor smaller-sized substrate particles, which would account for their predominance. Density reductions of the degree observed at all three stations also have been reported for similar situations by others.

A total of 103 periphyton taxa were identified from the three stations in 1983. The predominant periphyton (Achnanthes linearis, Achnonthes lanceolata var. dubia, Achnanthes minutissima, Navicula varidula var. Avenacea, and Nitzschia dissipata) are all indicators of high oxygen concentrations in alkaline streams. The presence of Achnanthes lanceolata var. dubia in large numbers during several sample periods generally indicates a low degree of relative organic enrichment in the areas sampled.

A high degree of annual variation of periphyton composition is apparent. While generally the same taxa dominated, they did so during different times in the season in 1983. The green algae, particularly Stigeoclonium tenue never reached the importance in 1983 that it had in previous years and Cocconics species did not reach the high density it had in past years. In addition Nitzschia species, which are characteristically indicative of higher organic enrichment, were not observed in large numbers in 1983. Most of these differences may be attributed to the rather unusual stream flow record in 1983 when periods of high flood were more frequent and prevalent. The water regime may also have had an effect on the abundance of the "nutrient lover" Nitzchia species through dilution effects.

A statistical comparison of 1983 biomass data with previous data showed that periphyton biomass was generally significantly higher during 1981 and 1982 than during 1983 (Table 9-6). This difference was probably due to the more frequent flooding in 1983 than in the previous two years.

Since the entire study area was severely impacted by flood, scour and/or siltation in 1983, valid comparisons of aquatic data are limited with respect to monitoring the effects of Tract C-b discharge. No definite trend in difference between Stewart Station (control) and Hunter Station (development) was established. Variations observed in the 1983 study seem to be attributable to natural factors, not the Tract C-b discharge.

TABLE 9-6

Comparison of 1983 Periphyton Density Data with 1981 and 1983 Data At Each Sampling Station During Each Sampling Period Using Fisher's LSD Procedure 1/

MONTH YEAR	STEWART STATION	MIDDLE STATION	HUNTER STATION
June			
1983 - 1982	2%	-	1%
1983 - 1981	-	-	5%
July			
1983 - 1982	2%	-	No Data - 1982
1983 - 1981	-	1%	1%
August			
1983 - 1982	1%	5%	No Data - 1983
1983 - 1981	-	2%	No Data - 1983
September			
1983 - 1982	-	1%	1%
1983 - 1981	-	-	-
October			
1983 - 1982	No Data - 1983	-	-
1983 - 1981	No Data - 1983	1%	1%

1/ 1 = No significant difference between years
5% = Difference significant at the 5% level
2% = Difference significant at the 2% level
1% = Difference significant at the 1% level

9.3.5 Air Quality

Trailer AB23 was the only air quality station active during 1983. It is co-located on-Tract with the 60-meter meteorological tower, as shown on Figure 9-14. Station AB23 has been in continuous operation since 1974, and monitors NO_x, NO, NO_2, O_3, SO_2, H_2S, CO and total suspended particulates (TSP). See Table 9-7 for a complete list of parameters measured and sampling and reporting frequencies.

Compliance with National Ambient Air Quality Standards was achieved in 1983 as indicated on Table 9-8. Data are shown for all years, including baseline. Ozone continues to be the only air quality parameter whose ambient levels reach a substantial fraction of the air quality standard. Since ozone is the product of atmospheric reactions and is also present in the stratosphere, rather than an emitted substance, its concentration is subject to variation due to: 1) stratospheric down-mixing, 2) changes in the intensity of insolation, providing the driving force for ozone-producing reactions, and 3) to long-range transport from industrial sources. This results in both a seasonal and diurnal pattern in the ozone levels, with the highest mean concentrations in summer (particularly in the heat of the day), and lowest in winter. Over the history of ozone monitoring on-Tract, this seasonal pattern coupled with the large random component has been consistently present.

Figure 9-15 is a histogram of ozone readings grouped by concentration class for 1982 and 1983. Eighty-one percent of all observations for 1982 and 1983 were less than 81 ug/m^3. Less than 3% of the observations in both years were greater than 100 ug/m^3.

Figure 9-16 is an ozone concentration rose by wind direction. Correlation of wind direction with ozone concentration is done to help determine if there are major regional patterns influencing ozone levels. Highest concentrations occurred for winds from the SSW sector, the prevailing wind direction on-Tract.

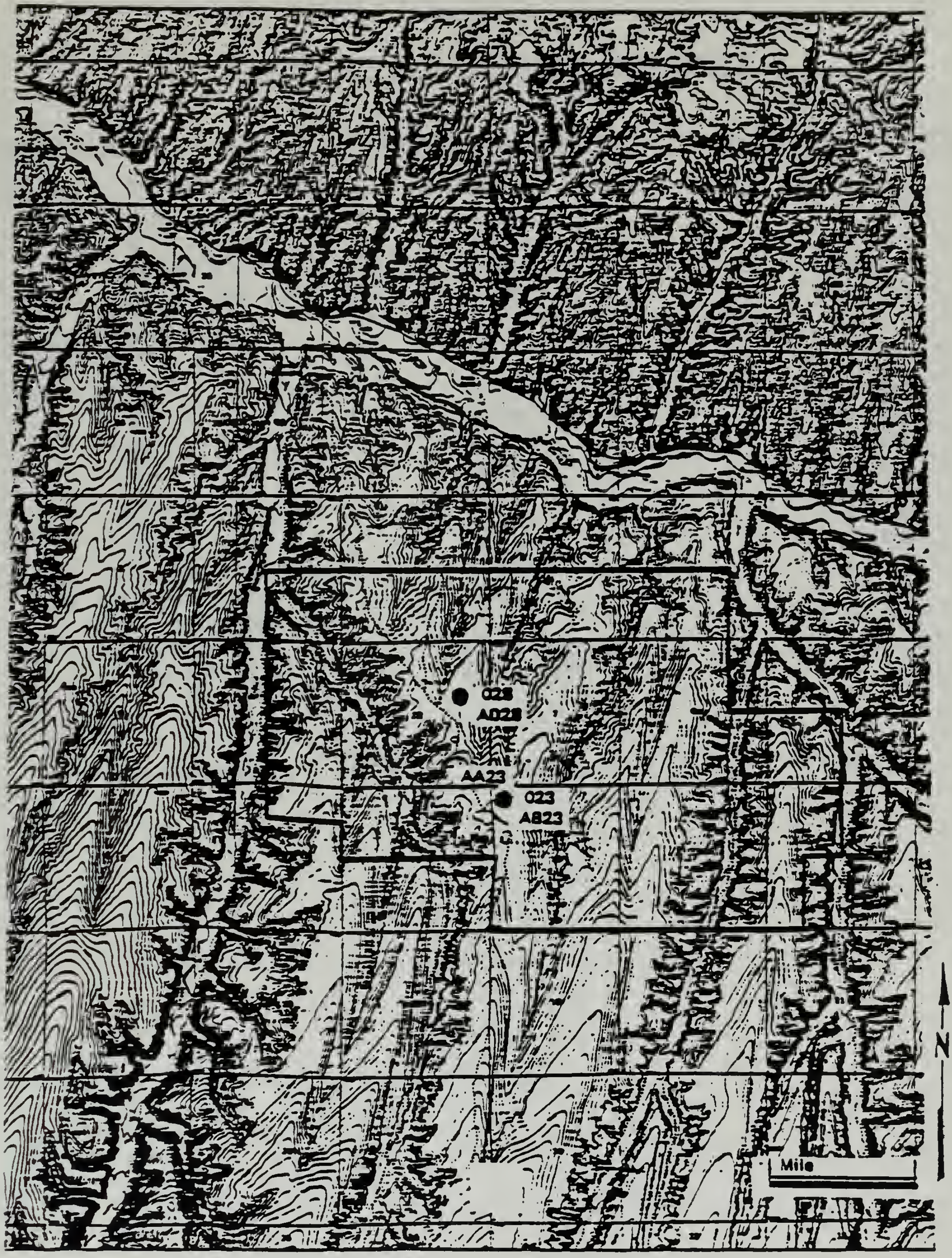


Figure 9-14

Ambient Air Quality
Interim Monitoring Network

TABLE 9-7

AIR QUALITY AND METEOROLOGICAL MEASUREMENTS

Station AA23		Sampling Frequency	Minimum Reporting Frequency
Tower:	(@ 10m, 30m, 60m)	5 sec	1 Hr Avg
	Wind Speed	5 sec	1 Hr Avg
	Wind Direction	5 sec	1 Hr Avg
	Temperature	5 sec	1 Hr Avg
	Delta Temp (60-10m)	5 sec	1 Hr Avg
Station AB23			
Trailer:	NO	5 sec	1 Hr Avg
	NO_x	5 sec	1 Hr Avg
	NO_2	NO_x-NO	1 Hr Avg
	O_3	5 sec	1 Hr Avg
	SO_2	5 sec	1 Hr Avg
	H_2S	5 sec	1 Hr Avg
	CO	5 sec	1 Hr Avg
	Barometric Pressure	5 sec	1 Hr Avg
	Solar Radiation	5 sec	1 Hr Avg
	Relative Humidity	5 sec	1 Hr Avg
	Particulates	24 Hr every 4 Days	24 Hr Total
	Precipitation	Continuous	1 Hr Total
Station AD28			
	Precipitation	Continuous	1 Hr Total

Table 9-8

Comparisons of Maximum Background Levels with National Ambient Air Quality Standards (Station AB23)

Time Period	Constituent	Standard Limit Primary	Standard Limit Secondary	Baseline Period 11/74-10/76	1977	1978	1979	1980	1981	1982	1983
	Averages ($\mu g/m^3$)										
Annual	SO_2	80.0		1.0[a]	0.3	1.3	0.4	1.0	1.5	1.4	1.8
	NO_2			1.5[a]	0.9	0.0	2.0	1.0	10.3[b]	2.7	1.3
	Particulates[c]	75.0	60.0	11.2[a]	6.7	9.1	13.3	7.0	10.2	7.5	6.5
	Max. Concentration ($\mu g/m^3$)										
1-hour	CO	40,000.0		3539.0	1530.8	4200.0	2900.0	3800.0	1800.0	600.0	140.0
	Oxidant (O_3)	235.[d]		152.	164.	161.	246.[e]	154.	155.	143.	135.
3-hour	SO_2		1300.0	88.0	17.6	24.0	16.4	13.1	18.3	15.7	13.9
8-hour	CO	10,000.0		2894.0	816.8	4000.0	1700.0	3000.0	1800.0	200.0	115.0
24-hour	SO_2	365.0		43.0	11.5	15.0	7.6	11.9	17.3	13.0	10.7
	Particulates	260.0	150.0	171.0	74.0	64.1	99.8	58.4	86.2	51.4	46.9

[a] Highest annual average during baseline period.
[b] <50% data.
[c] Geometric mean.
[d] Standard is exceeded if the number of exceedances of hourly values is $\geq$ 3 in a 3-year period.
[e] Only 1 value >235 to date.

Though recent particulate levels are well below ambient standards, high readings have been recorded particularly during baseline (see Table 9-8). High levels are attributed to fugitive dust. The 1983 particulate concentration rose (Figure 9-17) supports this conclusion, since the distribution is essentially independent of prevailing wind directions. Highest particulate concentrations are recorded during the summer months, when the wind is exhibiting its strongest influence of the year.

Histograms of particulate concentrations for 1983 and the 1974-1983 composite (Figure 9-18) show that 89% of the concentration readings are less than 25 ug/m^3.

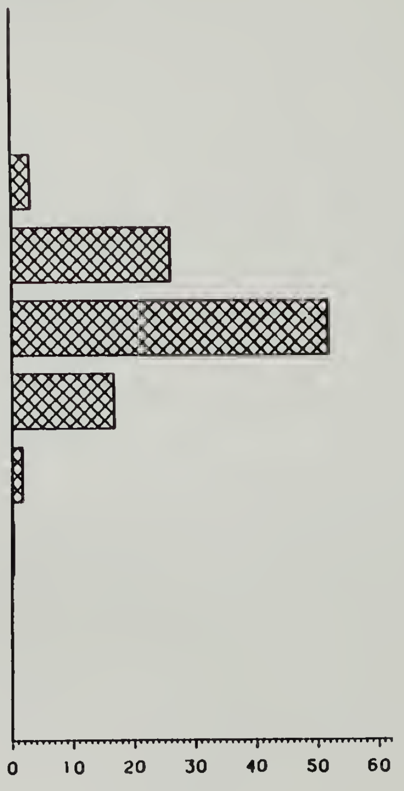
Linear regression analysis of all gaseous air quality parameters over time was performed for 1983 only (short-term) and for all data, including baseline (long-term). This was done to determine if any short-term or long-term linear trends existed. In all cases where trends were found to exist (95% confidence level), the strength of relationship (R^2) was less than 34%. Most R^2 values were less than 5%.

Consistent with past years, CO exhibited the strongest long-term trend (R^2 = 33%, negative correlation). This negative trend is attributed to instrument changes throughout the history of the monitoring period. The CO instrument used during baseline and shortly thereafter was relatively inaccurate and yielded high readings. This instrument has been replaced twice, and CO readings have dropped as instrument accuracy has improved. In any event, an R^2 value of less than 50% is not highly significant.

Quality assurance audits were conducted quarterly in 1983. Two were conducted by the State of Colorado, and two by the EPA, Region VIII. In every case, all CB gaseous instruments were within $\pm$ 7% of the audit instrumentation and particulates were within $\pm$ 13%. In addition to the quarterly audits, a CO audit was conducted in October, 1983 for a special EPA study. These results also indicated that the CO monitor was within $\pm$ 5% of the audit monitor.

HOURLY OZONE CONCENTRATIONS

1982

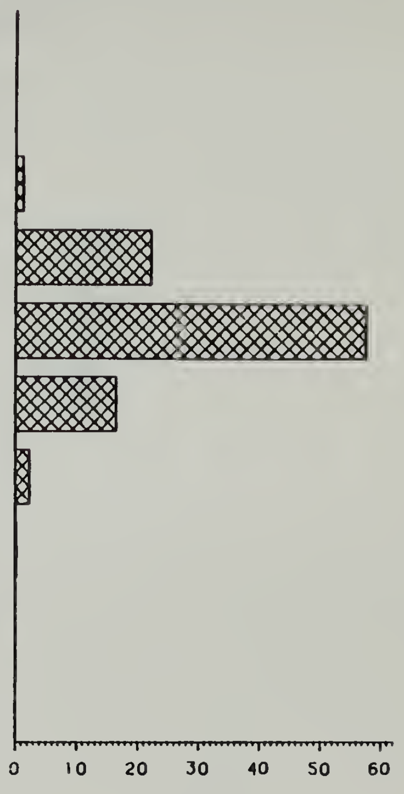


CONCENTRATION UG/M3*	No. Obs.	Cum. Obs.	% Total Obs.
2.9*	0	0	0.00
20.9	10	10	0.13
40.9	234	244	3.07
60.9	1994	2238	26.12
80.9	3969	6207	51.99
100.9	1281	7488	16.78
120.9	130	7618	1.70
140.9	15	7633	0.20
160.9	1	7634	0.01
161.0	0	7634	0.00

9-15a

HOURLY OZONE CONCENTRATIONS

1983



CONCENTRATION UG/M3*	No. Obs.	Cum. Obs.	% Total Obs.
2.9*	0	0	0.00
20.9	2	2	0.03
40.9	93	95	1.22
60.9	1692	1787	22.20
80.9	4393	6180	57.65
100.9	1260	7440	16.54
120.9	174	7614	2.28
140.9	6	7620	0.08
160.9	0	7620	0.00
161.0	0	7620	0.00

9-15b

*VALUES GIVEN FOR RANGE REPRESENT UPPER LEVEL OF RANGE

O_3 yearly mean = 68.7 μg/m^3

Five highest O_3 concentrations for 1982:

143.2 μg/m^3 - 8/7/82 @ 2400
137.3 " - 5/19/82 @ 1500
135.4 " - 5/19/82 @ 1600
135.4 " - 8/7/82 @ 2300
133.4 " - 2/10/82 @ 0700

O_3 yearly mean = 70.9 μg/m^3

Five highest O_3 concentrations for 1983:

135.4 μg/m^3 - 6/8/83 @ 1600
131.5 " - 6/2/83 @ 1500
121.6 " - 1/19/83 @ 1600
121.6 " - 6/2/83 @ 1700
121.6 " - 6/3/83 @ 1300

Figure 9-15

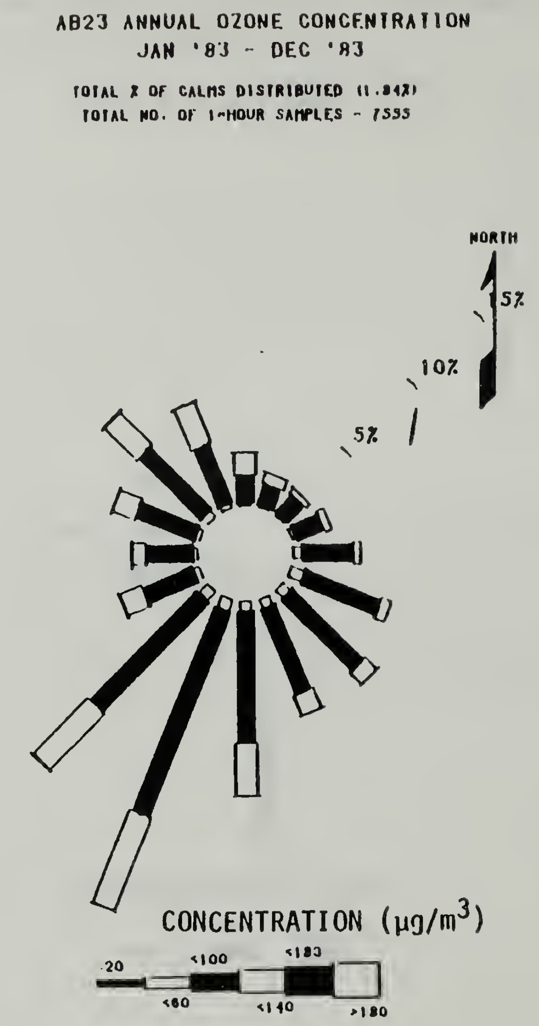

AB23 ANNUAL OZONE CONCENTRATION
JAN '83 - DEC '83
TOTAL % OF CALMS DISTRIBUTED (1.84%)
TOTAL NO. OF 1-HOUR SAMPLES - 7555
NORTH
5%
10%
5%
CONCENTRATION (μg/m³)
20
<60
<100
<140
<183
>180

Figure 9-16

AB23 ANNUAL PARTICULATE CONCENTRATION

JAN '83 - DEC '83

TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF DAILY SAMPLES - 82

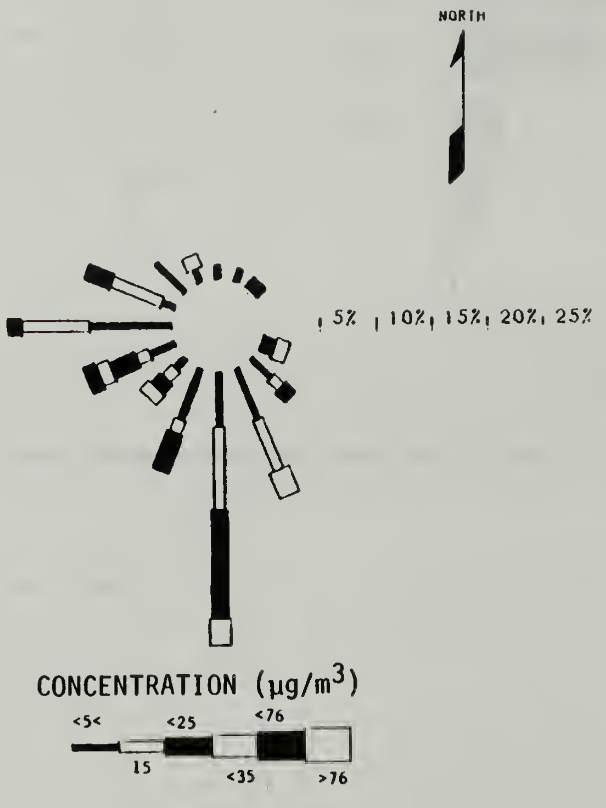
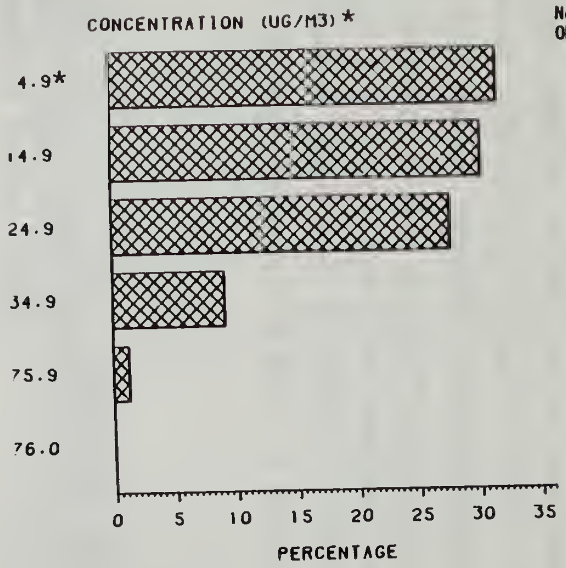


Figure 9-17

PARTICULATE CONCENTRATIONS

1983

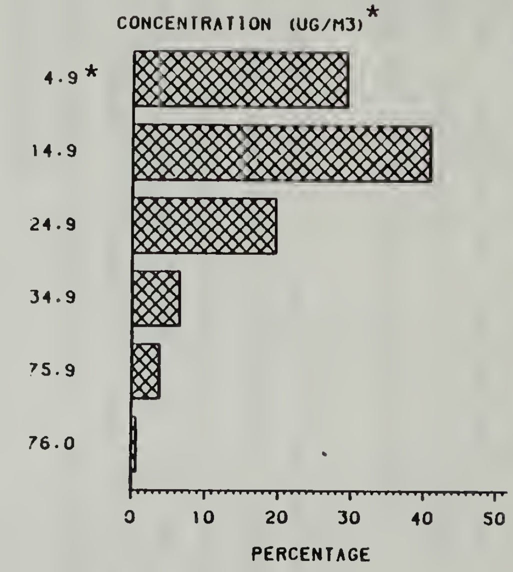


No. Obs.	Cum. Obs.	% Total Obs.
24	24	31.58
23	47	30.26
21	68	27.63
7	75	9.21
1	76	1.32
0	76	0.00

9-18a

PARTICULATE CONCENTRATIONS

1974-1983 COMPOSITE



No. Obs.	Cum. Obs.	% Total Obs.
459	459	29.16
639	1098	40.60
307	1405	19.50
101	1506	6.42
59	1565	3.75
9	1574	0.57

9-18b

*VALUES GIVEN FOR RANGE REPRESENT UPPER LEVEL OF RANGE

1983 annual geometric mean = 6.47

Five highest particulate concentrations for 1983:
9/19/83 - 46.9 μg/m^3
9/11/83 - 34.7 "
7/5/83 - 34.3 "
5/26/83 - 27.9 "
8/10/83 - 27.8 "

Figure 9-18

In April 1983, the Oil Shale Project Office approved conversion from the photographic to the telephotometric method of data collection for the visual range study. The photographic method was used through 1978. For the years 1975-1978 when no telephotometric measurements were made, "equivalent" telephotometric data were computed from the photographic data through regression analysis on photographic and telephotometric data which were collected simultaneously from 1979-1982. This regression analysis was completed for CB by Visibility Services, Inc. and previously reported.

Figure 9-19 is a set of time series plots which compare the actual measured and computed ("equivalent") telephotometric data for the period of 1979-1982. There are individual plots for each of the four views in the study. The first time period of the day, 0830 MST, was selected as a representative sample. Views I through III show close agreement between the measured and equivalent values. View IV is not as consistent. The four views are described in the data reports.

Table 9-9 shows mean seasonal visual range and annual visual range for all years since 1975. These are values obtained from the telephotometric method with "equivalent" data utilized in 1975-1978 using $C_m = 0.05$ as described below. Figure 9-20 is a histogram of daily mean visual range for 1983.

In 1983, the field technician's (i.e. observer's) estimate of the visual range was recorded in addition to that computed using the telephotometer. The two values differed by as much as 100%. Examination of the data revealed that the visual ranges computed from telephotometer contrast ratios were frequently beyond objects visible to the field observer. In the data reduction process, a constant which represents the contrast threshold of the eye (C_m) is used. The standard value used for this is 0.02. However, according to Tombach and Allard of Aerovironment[1], 0.05 is a more accurate estimate based on what the

[1] Tombach, I and D. Allard. Comparison of Visibility Measurement Techniques: Eastern United States, Aerovironment, Inc. October, 1983. Prepared for the Electric Power Research Institute. EA-3292. Research Project 862-15.

TIME SERIES PLOT OF ACTUAL AND ESTIMATED TELEPHOTOMETRIC VISUAL RANGE

VIEW I • 0830

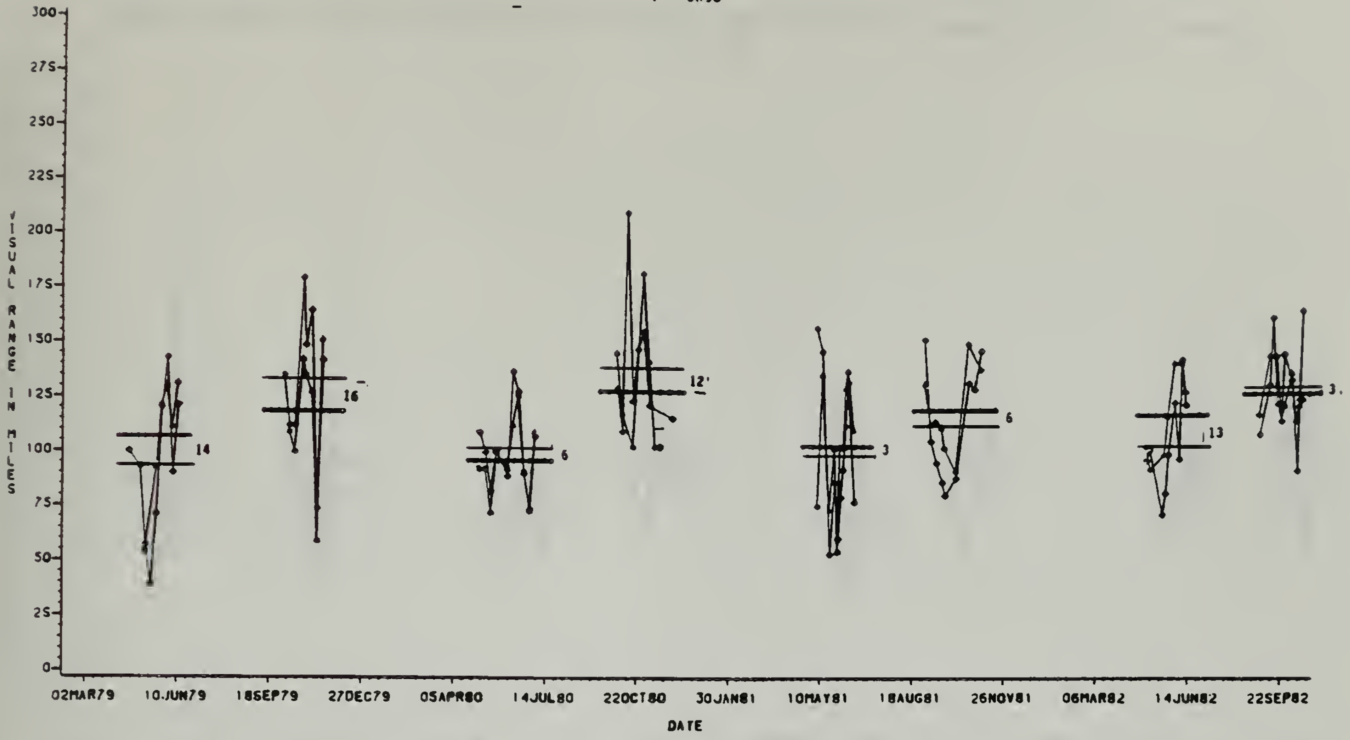


Figure 9-19

MEASURED - DIAMOND
ESTIMATED = STAR
SEASONAL AVERAGE -
SEASONAL AVERAGE =

TIME SERIES PLOT OF ACTUAL AND ESTIMATED TELEPHOTOMETRIC VISUAL RANGE

VIEW II • 0830

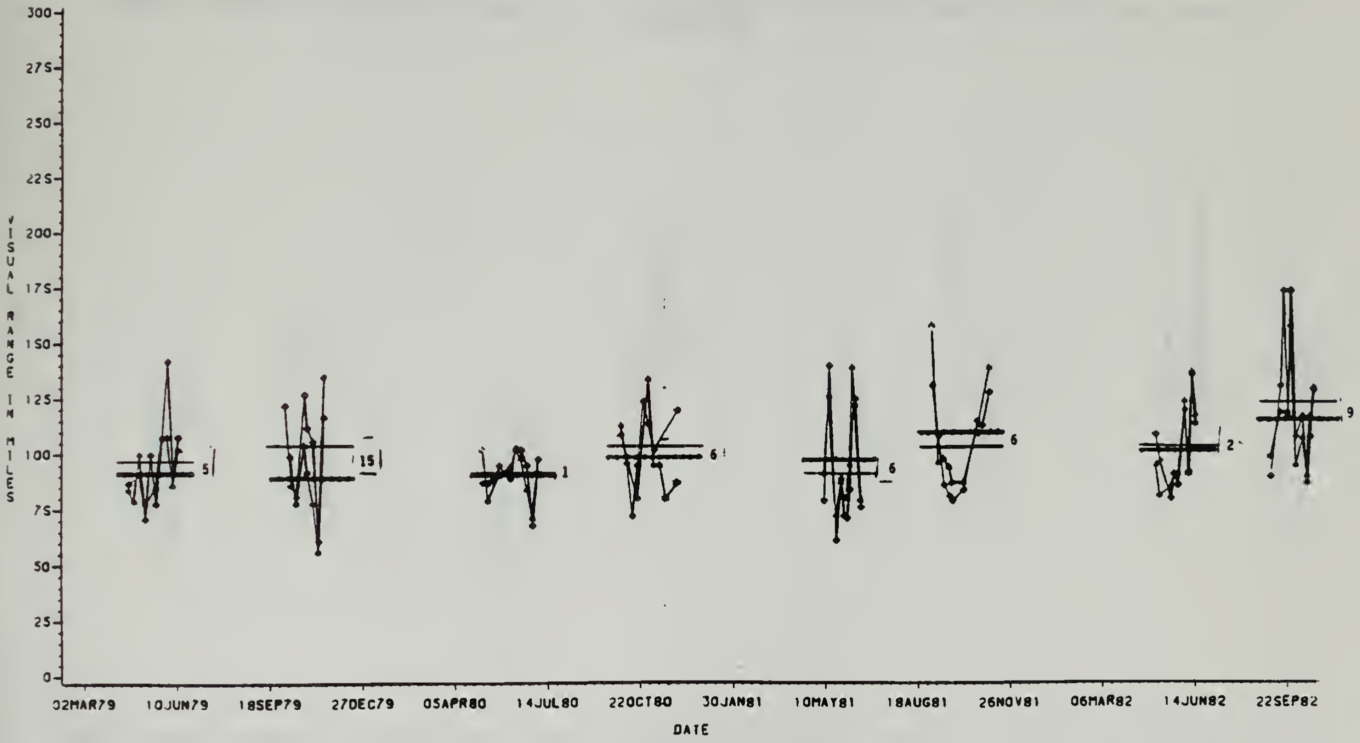


Figure 9-19

MEASURED = DIAMOND
ESTIMATED = STAR
EASONAL AVERAGE -
EASONAL AVERAGE =

TIME SERIES PLOT OF ACTUAL AND ESTIMATED TELEPHOTOMETRIC VISUAL RANGE

VIEW 131 • 0830

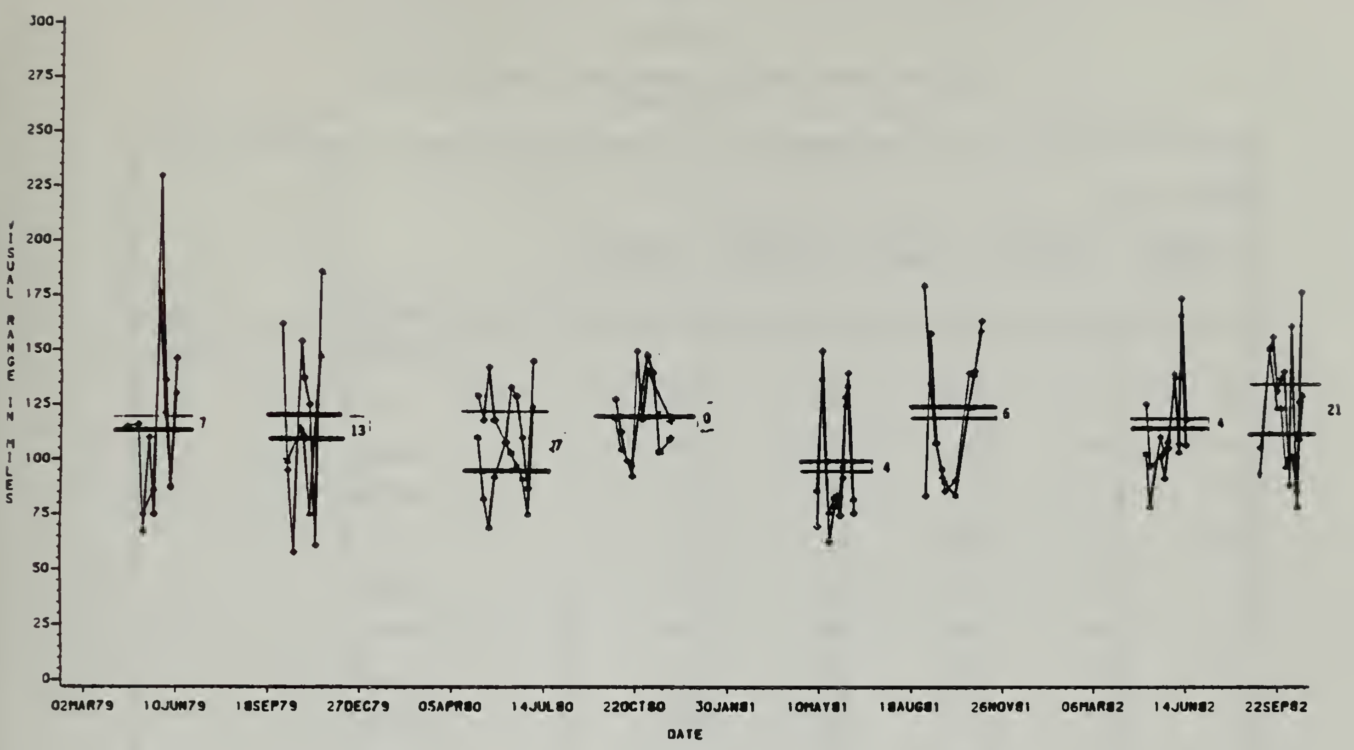


Figure 9-19

MEASURED = DIAMOND SEASONAL AVERAGE - ———
ESTIMATED = STAR SEASONAL AVERAGE = ═══

TIME SERIES PLOT OF ACTUAL AND ESTIMATED TELEPHOTOMETRIC VISUAL RANGE

VIEW LV • 0830

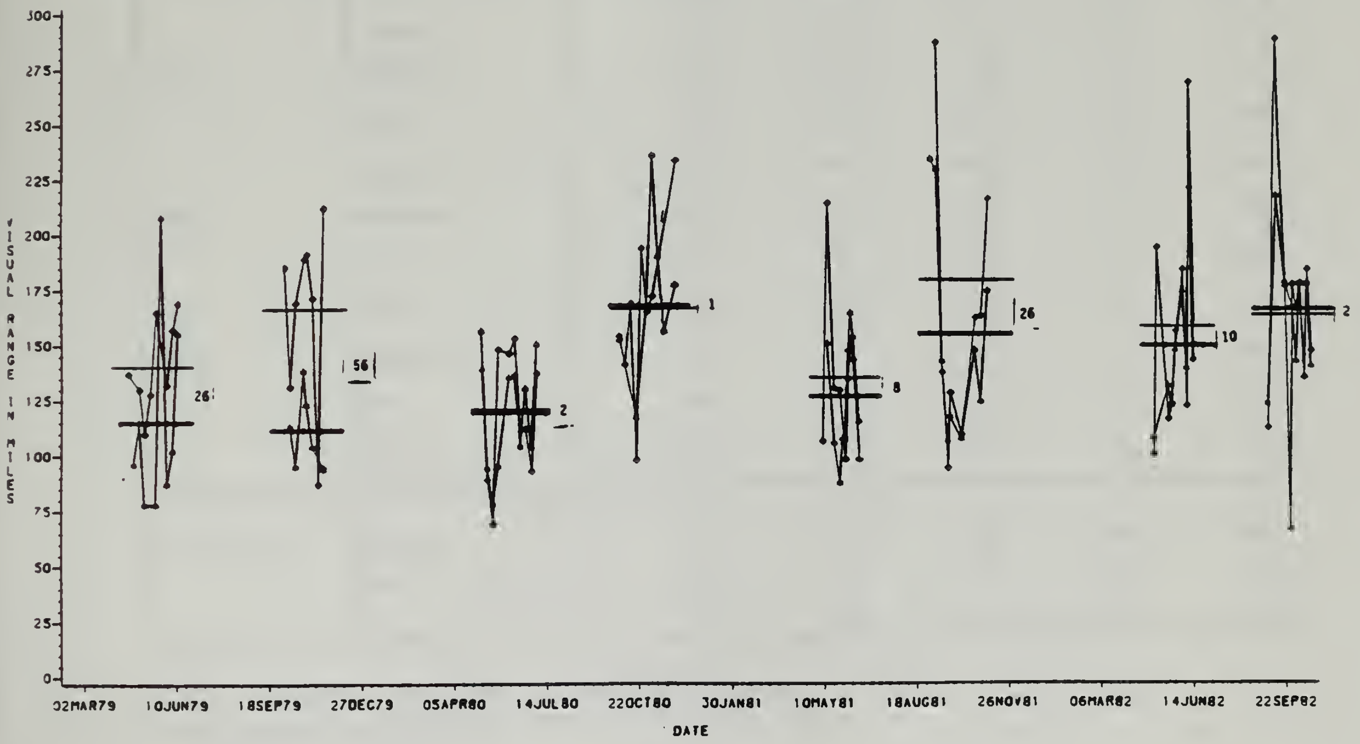


Figure 9-19

MEASURED = DIAMOND SEASONAL AVERAGE - ———
ESTIMATED = STAR SEASONAL AVERAGE = ═══

Table 9-9

MEAN SEASONAL AND ANNUAL VISUAL RANGE (MILES)[1]
1975-1983

YEAR	SEASON	VIEW 1 VISUAL RANGE	VIEW 2 VISUAL RANGE	VIEW 3 VISUAL RANGE	VIEW 4 VISUAL RANGE	ALL VIEWS VISUAL RANGE
1975 *	SPRING	.	.	.	.	.
	FALL	94	79	84	95	88
	YEARLY	94	79	84	95	88
1976 *	SPRING	78	70	.	81	76
	FALL	.	.	82	.	82
	YEARLY	82	72	73	84	78
1978 *	SPRING	84	76	72	86	80
	FALL	97	77	69	87	82
	YEARLY	89	76	71	86	81
1979	SPRING	80	71	79	115	86
	FALL	99	78	95	131	101
	YEARLY	90	75	87	123	94
1980	SPRING	81	68	78	107	83
	FALL	94	76	81	113	91
	YEARLY	87	72	80	110	87
1981	SPRING	71	66	67	94	74
	FALL	82	72	83	102	85
	YEARLY	77	69	75	99	80
1982	SPRING	80	75	81	110	86
	FALL	92	80	90	119	95
1982	YEARLY	87	78	86	115	91
1983	SPRING	82	70	61	74	72
	FALL	95	79	70	91	84
	YEARLY	88	75	65	82	78
ALL YEARS	SPRING	79	71	73	95	80
	FALL	93	77	82	105	89
	YEARLY	87	74	78	99	84

* Data are estimated "equivalent" telephotometric values.

(1) All historical data have been corrected using $C_m = 0.05$ as explained in the text.

[illegible]

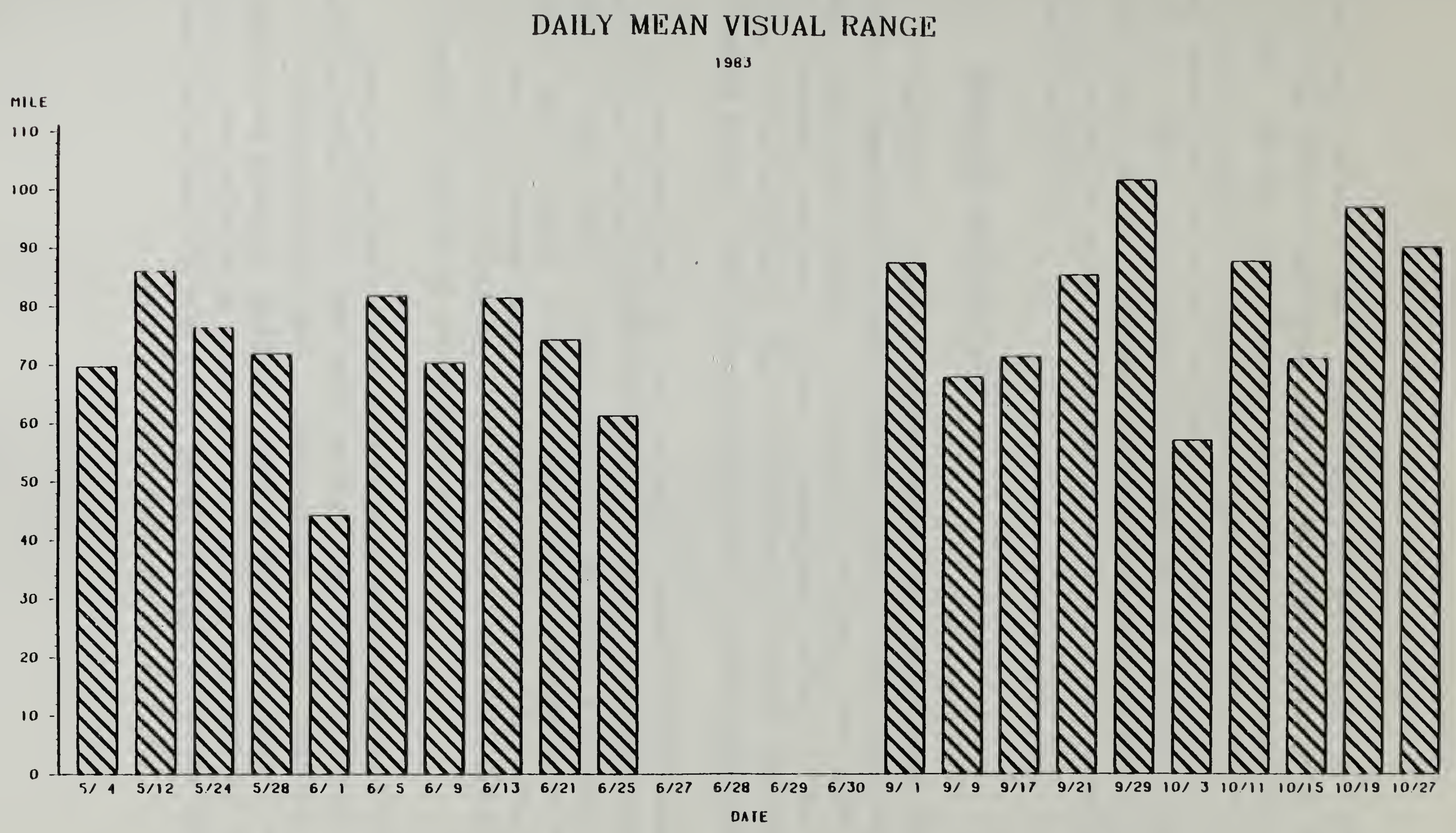

DAILY MEAN VISUAL RANGE
1983
MILE
110
100
90
80
70
60
50
40
30
20
10
0
5/ 4
5/12
5/24
5/28
6/ 1
6/ 5
6/ 9
6/13
6/21
6/25
6/27
6/28
6/29
6/30
9/ 1
9/ 9
9/17
9/21
9/29
10/ 3
10/11
10/15
10/19
10/27
DATE

Figure 9-20

global public actually "sees". Substitution of 0.05 results in values of visual range which are approximately 25% less than those derived using the 0.02 C_m value. The 1983 telephotometric visual range data were obtained using both contrast thresholds, and the visual range values were compared to the field technician's estimated visual range. The visual range values obtained using the 0.05 C_m were substantially closer to the observer's estimated visual range values, and therefore the 0.05 contrast ratio was used to compute all "equivalent" and actual telephotometric visual range data since 1975 as presented on Table 9-9.

9.3.6 Meteorology and Microclimate

Climatological parameters measured (Table 9-7) include wind speed and direction, temperature (and delta temperature from 60 to 10m), solar radiation, precipitation, relative humidity, and barometric pressure. These records serve as a historical data base to assess climatological effects on the biotic portion of the ecosystem so they may subsequently be sorted from potential man-induced effects. Hourly values are reported in the 6-month data reports.

The wind data are also used to obtain Pasquill-Gifford atmospheric stability and wind persistence information for use in air diffusion modeling studies. Figure 9-21 is a annual wind rose, and Figure 9-22 contains wind roses by stability class. Prevailing winds on-Tract continued to be from the SSW. Those in Piceance Creek are constrained to follow the valley walls. Tract C-b's stability factor generally ranges from stable (i.e., Classes E and F) to neutral (Class D), as seen on Figure 9-22.

There are four microclimate stations being monitored during the Interim Monitoring Period - BC03, BC05, BC07, and BC09. One station is located in each of the following habitat types: pinyon-juniper, chained rangeland, upland sagebrush, and bottomland sagebrush. Specific locations are noted in the data reports. Data collected at these stations indicate that 1983 was slightly colder than average, with some below-freezing temperatures recorded during the

AA23 ANNUAL WIND ROSE @10 M
All Stability Classes
JAN '83 - DEC '83

TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1-HOUR SAMPLES - 8477

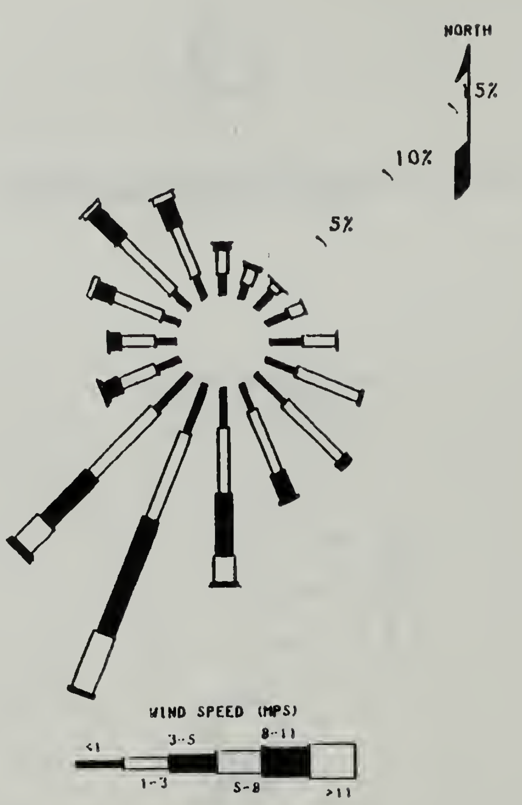


Figure 9-21

AA23 ANNUAL WIND ROSE @ 10M
Stability Class A
Jan. '83 - Dec. '83

Total No. of 1 hour samples in Stability Class A = 532
Percent occurrence for year = 6.3%

AA23 ANNUAL WIND ROSE @ 10M
Stability Class B
Jan. '83 - Dec. '83

Total No. of 1 hour samples in Stability Class B = 1108
Percent occurrence for year = 13.1%

AA23 ANNUAL WIND ROSE @ 10M
Stability Class C
Jan. '83 - Dec. '83

Total No. of 1 hour samples in Stability Class C = 559
Percent occurrence for year = 6.6%

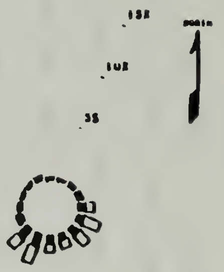
AA23 ANNUAL WIND ROSE @ 10M
Stability Class D
Jan. '83 - Dec. '83

Total No. of 1 hour samples in Stability Class D = 2248
Percent occurrence for year = 26.5%

AA23 ANNUAL WIND ROSE @ 10M
Stability Class E
Jan. '83 - Dec. '83

Total No. of 1 hour samples in Stability Class E = 2479
Percent occurrence for year = 29.2%

AA23 ANNUAL WIND ROSE @ 10M
Stability Class F
Jan. '83 - Dec. '83



Total No. of 1 hour samples in Stability Class F = 1551
Percent occurrence for year = 18.3%

WIND SPEED (MPS)

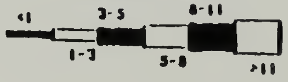


Figure 9-22

AA23 Annual Wind Rose @10M
by Stability Class

growing season. Snow depth and snow moisture content for 1983 were 22% and 31% (respectively) lower than the average for the last four years as measured at the Tract; snow depth at the Little Hills and Meeker stations were higher than normal however. Precipitation was 30% above the average for the last six years, with high rainfall occurring during the spring months. This heavy spring precipitation accompanied by a late snow melt contributed to the cause of spring flooding in Piceance Creek.

9.3.7 Noise

The environmental noise program was discontinued during the Interim Monitoring Period.

9.3.8 Wildlife Biology

The wildlife monitoring program for 1983 consisted of studies on mule deer, lagomorphs, small mammals, raptors, browse and mitigation effects. Results and discussions of these wildlife studies will be presented in the July, 1984 data report. A summary of the findings is presented below.

Results of the deer pellet-group counts show that the 1982-83 pellet densities were the highest (465 pellet groups/acre) since the study was started in 1974. Examination of the results of the study indicate no appreciable displacements of deer due to Tract development.

Determinations of the success of the sagebrush-beating mitigation technique have been evaluated for the past two years with no apparent increase in numbers of deer (higher pellet-group densities) in the brush-beaten areas (Table 9-10). The 2-level analysis of variance (ANOVA) conducted this year indicated no significant differences between treatment and control areas ($F = 0.31$; $df = 1, 7$; $P > 0.50$).

Table 9-10

Comparison of Mule Deer Pellet-Group Counts Between Brush-Beaten Sagebrush With Control Areas

TWO-LEVEL NESTED ANOVA:

Source of Variation	DF[1]	MS[2]	F[3]	Variance Components
Between brush-beaten and control areas	1	0.33	0.31	6.4%
Among subgroup plots	7	1.05	15.01	38.6%
Within plots	171	0.07		55.1%

F (.05; df=1,7) = 5.59 F (.05; df=7,171) = 2.07

Transect Means +/- SE[4](n) =

Brush-beaten		Control	
BA41[5]	85 +/- 23 (20)[6]	BA43	60 +/- 22 (20)
BA42	325 +/- 83 (20)	BA44	630 +/- 78 (20)
BA45	110 +/- 46 (20)	BA47	295 +/- 49 (20)
BA46	175 +/- 51 (20)	BA48	130 +/- 33 (20)
		BA49	60 +/- 13 (20)

[1] DF = Degrees of Freedom

[2] MS = Mean Square Error

[3] F = Test of Significance

[4] SE = Standard error of the mean

[5] BAXX = Station computer code

[6] Table expressed as Mean Value $\pm$ SE(n) where n is the number of samples.

The overall percent utilization rate of bitterbrush by deer on the Tract was 78%. This utilization was intermediate in terms of the range of variation when compared to previous data. Bitterbrush utilization was again typically higher in the chained pinyon-juniper habitat than in the pinyon-juniper habitat (80% vs. 72%, respectively).

Sagebrush utilization rates in the medium and high categories are still continuing to decrease. The number of decandent plants along the transect are also decreasing. Analyses performed on the data included time series, multiple regression and correlation between sagebrush and bitterbrush utilization and pellet group density. Comparisons of these results with previous yearly findings indicate C-b activities are not adversely affecting sagebrush growth or utilization rates.

The accumulative count for the deer road study was the highest total in the six year period of the study (13,107 deer). The previous high occurred in 1978-79 (12,815). The single day count of 1,907 deer is the highest recorded since it began in 1977. An interesting trend is becoming apparent in that the highest fall count has occurred during the third week of October for five of the last six years. The high spring counts have fluctuated greatly, probably depending on the date of emergence of the grass. Comparisons of the deer phenology and distribution data with previous years' results indicate no displacement of deer due to developmental activites.

Deer roadkill (Figure 9-23) was slightly higher this year compared to 1982 (60 vs. 54, respectively). The class breakdown of kills was similar to previous years; highest number of kills were the does and the fawns. No adult bucks were killed this year. Traffic load along the highway was similar to last year.

Similarly to the previous year, only four of the ten deer mortality transects were sampled. Three carcasses were found in 1983. This is probably a reflection of the fairly mild winter and a healthy herd.

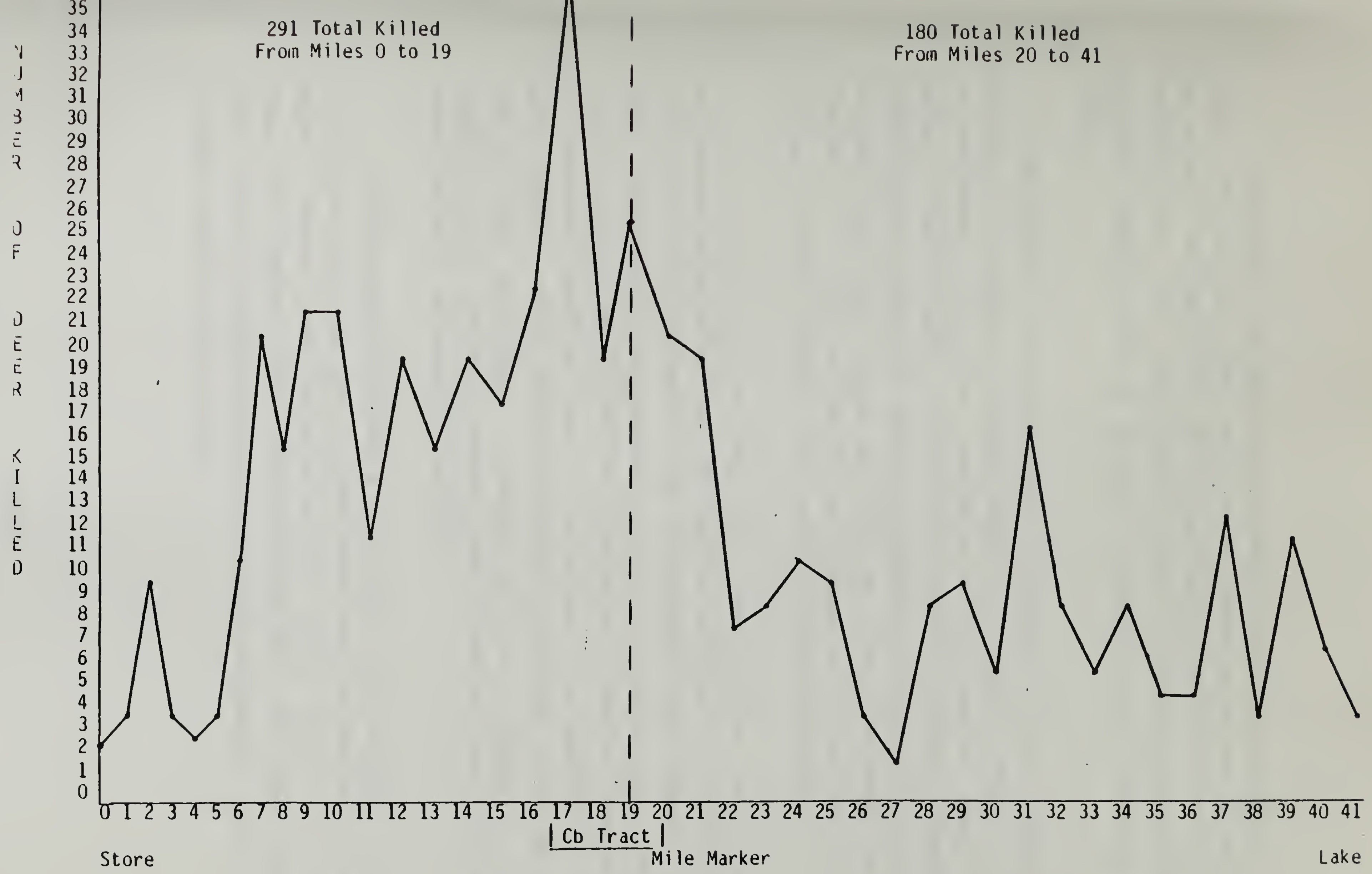


Figure 9-23
Accumulative Piceance Creek Road Kill (1977-83)

The results of the age class study were typical of a comparatively mild winter. The fall fawn-to-adult ratio was 56 compared to 28 fawns/100 adults in the spring. The sample size for the age classes tends to be small for the fawn/adult ratio. Thus, caution should be taken in using the data for anything more than supportive data to be used in conjunction with the other deer studies.

The cottontail pellet count data for the past five years (Table 9-11) are beginning to suggest correlations among the four habitats sampled. Results are preliminary at this time; correlations will be done next year to test whether all habitats agree in terms of yearly trends in abundance. Comparisons between the brush-beaten and unmodified sagebrush have been made for the past two years (Table 9-10). Results show lower use in the brush-beaten plots ($t = 4.38$, $df = 7$; $P < 0.005$ for 1982-83), which appears to indicate that the brush beatings are having a negative effect on the cottontail population.

The objective of the 1983 small mammal studies was to better characterize habitat affinities. The question asked was: are there habitat features pertinent to reclamation that are important to small mammals? Eight habitat characteristics were measured in each of five habitat types. Multiple regression analysis was used to find a combination of habitat characteristics that explained a significant amount of the variance in the abundance of a small mammal species. Habitat variables identified as important to the deer mouse were loose rock and shrubs. No habitat variables of importance to least chipmunks could be identified; however, areas avoided were those with abundant grasses and forbs, and areas with conifers.

The 1983 raptor study showed 8 active nests, which included: five pairs of red-tailed hawks, one pair of great horned owls and two pairs of golden eagles. Numerous hawks (including kestrels, marsh, Swainson's and rough-legged) were observed in the study area during 1983. The raptor population seems to be fairly stable with no effects of C-b developmental activities on the raptor population being evident.

TABLE 9-11

Cottontail Trends Based on Pellet Count Frequencies [1]

Year	HABITAT Chained rangeland	Pinyon-juniper	Brush-beaten sagebrush	Sagebrush control
1978-79	8+/-1.2 (18)	11+/-1.6 (12)	-	-
1979-80	12+/-0.9 (15)	11+/-1.3 (12)	-	-
1980-81	9+/-0.7 (18)	13+/-0.8 (12)	3+/-0.9 (4)	12+/-3.1 (5)
1981-82	7+/-1.0 (18)	11+/-1.4 (12)	1+/-0.4 (4)	9+/-2.7 (5)
1982-83	13+/-1.0 (18)	15+/-0.8 (12)	3+/-1.3 (4)	14+/-2.1 (5)
Average	10+/-0.96	12+/-1.2	2+/-0.9 (4)	12+/-2.6 (5)

[1] Data are means +/-SE (n). Means are based on the number of quadrats with droppings present; n = number of transects. A transect consists of 20 circular quadrats, 0.001 acre each. SE = Standard Error of the Mean.

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

Analysis of the wildlife data indicate that developmental activities on C-b Tract have not significantly affected the various wildlife species using the Tract area. The factors of minimal disturbance by these species (less than 200 acres) and little observed effect on the wildlife populations seem to indicate that this year's data could still be used as pre-development data (baseline information).

Concerning threatened or endangered plant species, no species were observed on C-b Tract. Sandhill cranes and bald eagles were again seen in the Tract vicinity.

A new brush beating project was planned this year. A 100 acre area of serviceberry is scheduled to be beaten in 1985 to increase the browse production for deer and elk. Presently, the serviceberry averages 6-10 feet in height, providing little new growth for utilization by big game species, since it is out of reach of the animals. Beating the brush in the area should stimulate new growth on the shrub species providing more forage to the deer and elk. Six deer and browse transects (three developmental and three control - outside of the beating area) were established in the fall of 1984. These transects will be used to obtain baseline information for the area, and then, in succeeding years, to test the success of the project.

9.3.9 Vegetation

Vegetation monitoring studies have been conducted yearly on the C-b Tract since 1974. Studies have focused on monitoring trends in herbaceous production and changes in community structure and species composition in the major plant communities on the Tract. In 1978 a concept was implemented to obtain a more broadly based estimate than was derived from previous intensive study plots. From 1978 to 1981, the monitoring studies were based on intensive study plots and broad vegetation-type sampling as a whole. In 1982 the only studies which were continued were the production/utilization measurements in the chained rangeland type, the irrigation and fertilization production studies, and the cover and density studies in the irrigated chained rangeland intensive study plot. Since there was no disposal of excess mine water by irrigation in 1983, the only monitoring studies which were continued were the production/utilization studies in the chained rangeland type.

Mean total production for the 15 range cage and adjacent open areas in the chained rangeland type was 35.6 g/m^2 (318 lbs/acre) in the open areas and 69.8 g/m^2 (623 lbs/acre) inside the range cages. Based on a one-way analysis of variance these two means are significantly different at an 0.05 level of significance. (The critical region for this test is that for which the F-value is greater than 4.21. The calculated F for this test was 4.72.) Based on data from the range cages, the production in the chained rangeland type was comparable to the results obtained in earlier years (Figure 9-24). It is interesting to note that the value of 69.8 g/m^2 is the highest value measured in the six years that the range cages have been used on the Tract. Between 1979 and 1982, production ranged between approximately 42 and 46 g/m^2. In 1978, mean production in the chained rangelands was approximately 62 g/m^2 (Figure 9-24). Data for the range cages and open areas were reported in the January 15, 1984 CB Data Report.

9.3.10 Revegetation

Revegetation monitoring studies for 1983 were conducted for four topsoil storage embankments (two embankments were in the fifth growing season and the other two in the third growing season) and two revegetation demonstration test plots. The two test plots include: evaluation of revegetation success of raw oil shale under three different topsoil treatments, and evaluation of revegetation success on processed (spent) shale under different topsoil and sewage sludge application treatments.

9.3.10.1 Raw Shale Demonstration Test Plot and Leachate Studies

9.3.10.1.1 Raw Shale Demonstration Test Plot

The raw shale demonstration test plot study was designed to evaluate the effect of three different topsoil depths on the success of revegetation. The study was initiated in the fall of 1981. The demonstration test plot was constructed on the south-facing side of the raw shale stockpile located south of the CB offices. The plot is approximately 50 by 50 feet in size, and the

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

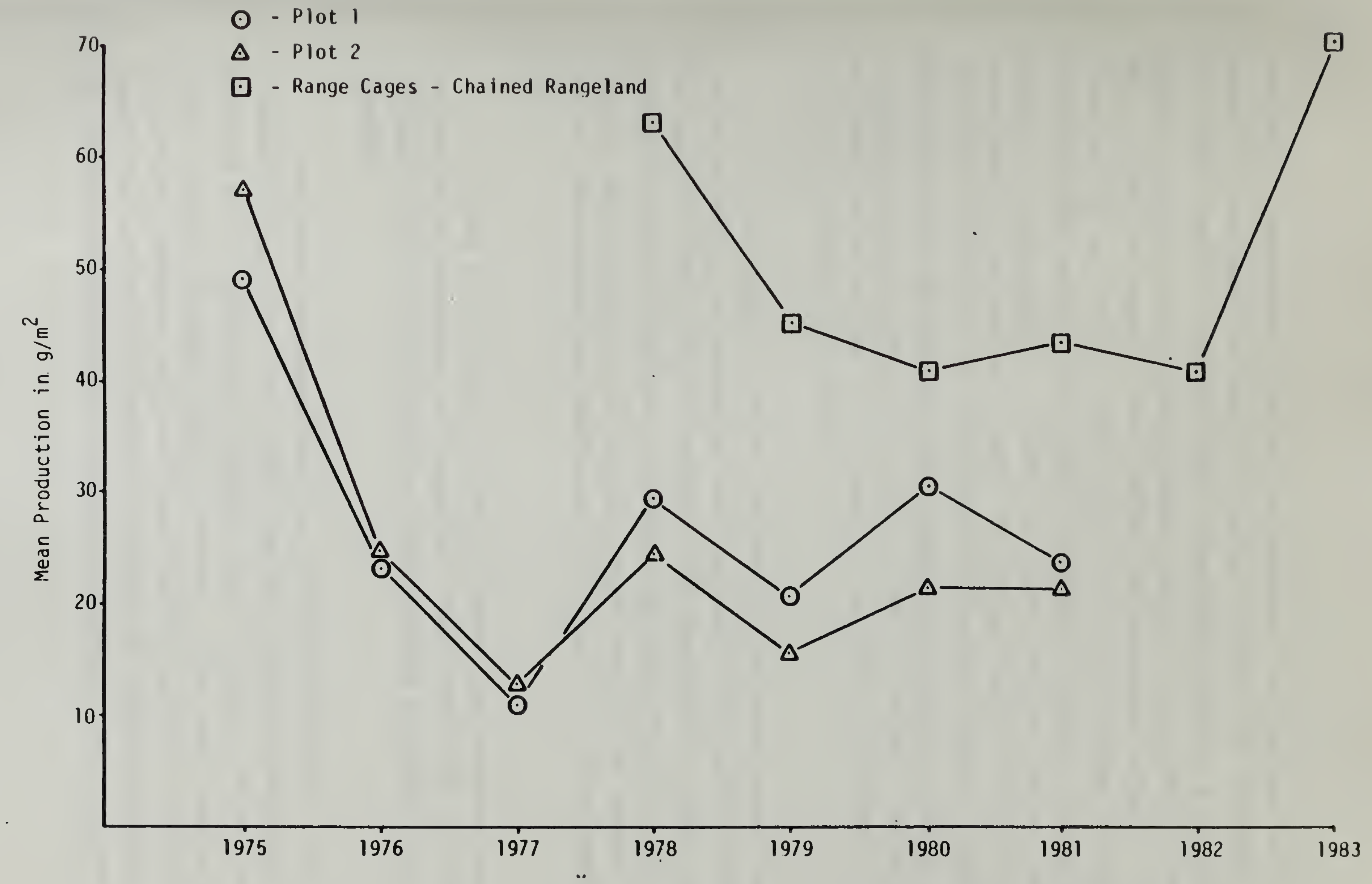


Figure 9-24 Trends in Mean Herb Production Between 1975 and 1983 for Chained Pinyon-Juniper Rangelands.

raw shale is approximately 5-8 feet in thickness. The plot was covered with three different depths of topsoil (6-inches, 12-inches, and 18-inches). The plot slopes gently to the south with an approximate slope of 8:1. After the topsoil was spread, the plot was broadcast seeded. The species are listed in the July 1984 Data Report. After seeding, the plots were mulched. Excelsior fiber matting was utilized rather than straw or hay in order to reduce the number of annual weeds. During 1982, the plot was irrigated on an "as needed" basis with approximately 3-inches of water applied during 1982 and approximately 1-inch applied in 1983. The plot was fenced to eliminate grazing by domestic livestock. The fencing does not exclude rabbits. Observations made during the 1983 growing season suggest that grazing by rabbits may be influencing the total production values. In the fall of 1983, the entire plot was fertilized at the rate of 100 pounds of available nitrogen and 100 pounds of available phosphorus per acre.

The 1983 sampling program consisted of obtaining cover, frequency, species diversity, and production data from each of the topsoil treatments. The sampling methods used are consistent with those used for other cover and production studies on the Tract. Production data were obtained using a double sampling method using 0.1 m^2 quadrats rather than 1.0 m^2 quadrats. The smaller sized quadrats were used because of the small size of the demonstration plot.

The data from the test plot were evaluated using a one-way analysis of variance which tested the null hypothesis that there were no significant differences among the mean production values obtained from each of the topsoil treatments.

Mean total herbaceous cover was consistent among the three topsoil treatments. Mean total cover ranged from 19.0 percent on the 6-inch topsoil treatment to 17.3 percent on the 12-inch topsoil treatment. Mean cover of the 18-inch topsoil treatment was 17.6 percent. The major species are the wheatgrasses (Agropyron spp.) which were combined because of difficulties in identifying the individual species on the basis of vegetative characteristics. The wheatgrasses accounted for 72 percent, 59 percent, and 73 percent of the

total cover on the 6-inch, 12-inch, and 18-inch treatments, respectively. The other major species was alfalfa (Medicago sativa), which accounted for most of the remaining cover on the three treatment blocks. The 18-inch topsoil treatment had the highest number of species (10); the other two treatments each had six species. Of the species planted, the wheatgrasses performed the best. Great Basin wildrye and Russian wildrye were not identified in the sampled quadrats in any of the treatments. Annual weeds comprised an insignificant component of the vegetation on the test plot.

The production and cover data for the raw shale test plot are reported in the January 15, 1984, Data Report. Mean total production was highest in the 18-inch treatment (130.8 g/m^2 - 1167 lbs/acre) followed by the 6-inch treatment (103.0 g/m^2 - 919 lbs acre) and the 12-inch treatment (87.7 g/m^2 - 782 lbs/acre). It is clear that the gradient of values does not match the topsoil depth gradient. These differences were tested using a one-way analysis of variance and were found to be significant. (The test was made at a 0.05 level of significance. The critical region for rejecting the hypothesis is for F values greater than 3.16. The calculated F value was 7.71.) The differences in means were then evaluated using a Student-Newman-Keuls range test at a 0.05 level of significance. This test allows for determination of which mean or groups of means are significantly different from one another. The results of this test showed that the mean for the 18-inch topsoil treatment was significantly greater than the means for either the 6-inch or 12-inch treatments, but there was no significant difference between the 6-inch and 12-inch topsoil treatments. These preliminary results suggest that 18-inches of topsoil are necessary to make a difference in total production.

In all cases the greatest percent of total biomass was attributable to the wheatgrass species. Alfalfa accounted for most of the rest of the production.

9.3.10.1.2 Raw Shale Leachate Studies

The raw shale leachate collection system was constructed at the C-b Tract in December, 1980. The collection system includes three collectors buried beneath raw shale at depths of 10, 15, and 20 feet. The study was

originally conceived as a cooperative three year project among CSU, EPA, OSPO, Rio Blanco Oil Shale Co. (RBOSC), and CBSOC. The purpose of the study, as well as the experimental design and methods of analysis have been described previously in the 1981 CB Annual Report, Volume 2. The following is a summary of the results from the final report: Quality and Quantity of Leachate From Raw Mined Colorado Oil Shale, by David B. McWhorter, CSU, EPA Grant No. R807513.

Precipitation and Leachate Volume

The total volume of leachate collected over the study period at C-b ranged from 11.52 cm to 17.02 cm, and represents 12% and 17% of the total precipitation, respectively. Such volumes of percolate are large in the perspective of anticipated natural recharge rates for the area. The relatively large volumes are attributed to the fact that the piles are very pervious and bare of vegetation, both of which tend to minimize runoff and evapotranspiration losses that operate on the undisturbed ground.

The close agreement between measured volumes of leachate from the 15 ft. and 20 ft. collectors on the C-b Tract suggest that the volumes measured in these two collectors are the most reliable volume data collected in the study.

Electrical Conductivity and pH - The electrical conductivity values from the C-b lysimeters average 6,950 umhos/cm. The pH ranged from 7.4 to 8.4.

Quality of leachate - Throughout the study period, samples from bottles A, B, and C were collected and many of them were prepared for chemical analysis. Analyses of waters contained in bottles B and C did not often differ significantly from those of bottle A water.

The composition of the C-b leachates is dominated by sodium and sulfate. It appears that the calcium concentration is controlled by the solubility of calcium sulfate.

The concentration of nitrates in the leachate from C-b is greater than was anticipated. One obvious source for nitrates is the residual from explosives used in mining the shale. If this is indeed the major source, it is expected that a trend toward lower nitrate concentrations should be observed as a result of washing the residual explosive from the particle surfaces. Throughput volumes to date are too small to expect observation of a decreasing trend at this time.

Fluoride concentrations in C-b leachate ranged from 4.2 to 10.5 mg/l and the data do not show any trend with depth of collector. The concentrations of fluoride observed in the field-generated leachates are similar to those measured in a previous column leaching study, although the raw shales in the columns were not duplicates of those that overlay the collectors.

Concentrations of zinc and boron are significantly less than the maximum values observed for these elements in the previous column leaching tests. Again, the difference results from differences in materials used in the two studies. The molybdenum data at C-b show a significant decreasing trend with time in 1981, but recovered in 1982. No reliable time trends toward lower concentrations are discernible in the trace element data. Again, it is emphasized that only a small volume of leachate has been collected relative to the pore volume of the shale overlying each collector.

Summary and Conclusions

It is emphasized that the results and conclusions reported herein are specific to the shales studied. Extrapolation of the results or conclusions to other conditions is not recommended.

1) The cumulative volume of leachate per unit area measured over nearly three years at C-b ranged from 11.52 to 17.02 cm. These volumes represent 12 and 17 percent, respectively, of the incident precipitation over the same time period.

2) Leachate volumes of the above magnitudes are believed to be larger relative to the natural recharge rates on undisturbed lands receiving similar volumes of precipitation. The raw shale piles were formed from mine-run size material and remained unvegetated. Therefore, infiltration capacity was high and both evapotranspiration and direct runoff capacity were low.

3) The C-b leachate is a sodium-sulfate solution with an average concentration of dissolved solids of 6850 mg/l. The pH ranged from 7.4 to 8.4.

4) Trace element concentrations in leachate were generally low in view of the large concentrations of the common ionic species. Although the concentrations of many trace elements were sometimes observed to be greater than the various recommended maxima for particular uses, the large concentration of common species is ore likely to be the significant quality characteristic of those waters.

5) No trends toward improvement in water quality with time were observed. The volumes of leachate generated in the study period are small relative to the pore volume of the shales overlying the collectors. Improvement in quality is not likely until the volumeof leachate exceeds at least 0.5 pore volumes.

A more complete disucssion of the raw lysimeter tests at C-b Tract, as well as tests conducted on C-a Tract mined raw shale and laboratory leaching tests is contained in the previously mentioned report by Dr. McWhorter. Also, a complete set of data tables and graphs on C-b leachates from the McWhorter report will be presented in the July, 1984 CB Data Report.

9.3.10.2 Processed Shale Demonstration Test Plot and Leachate Studies

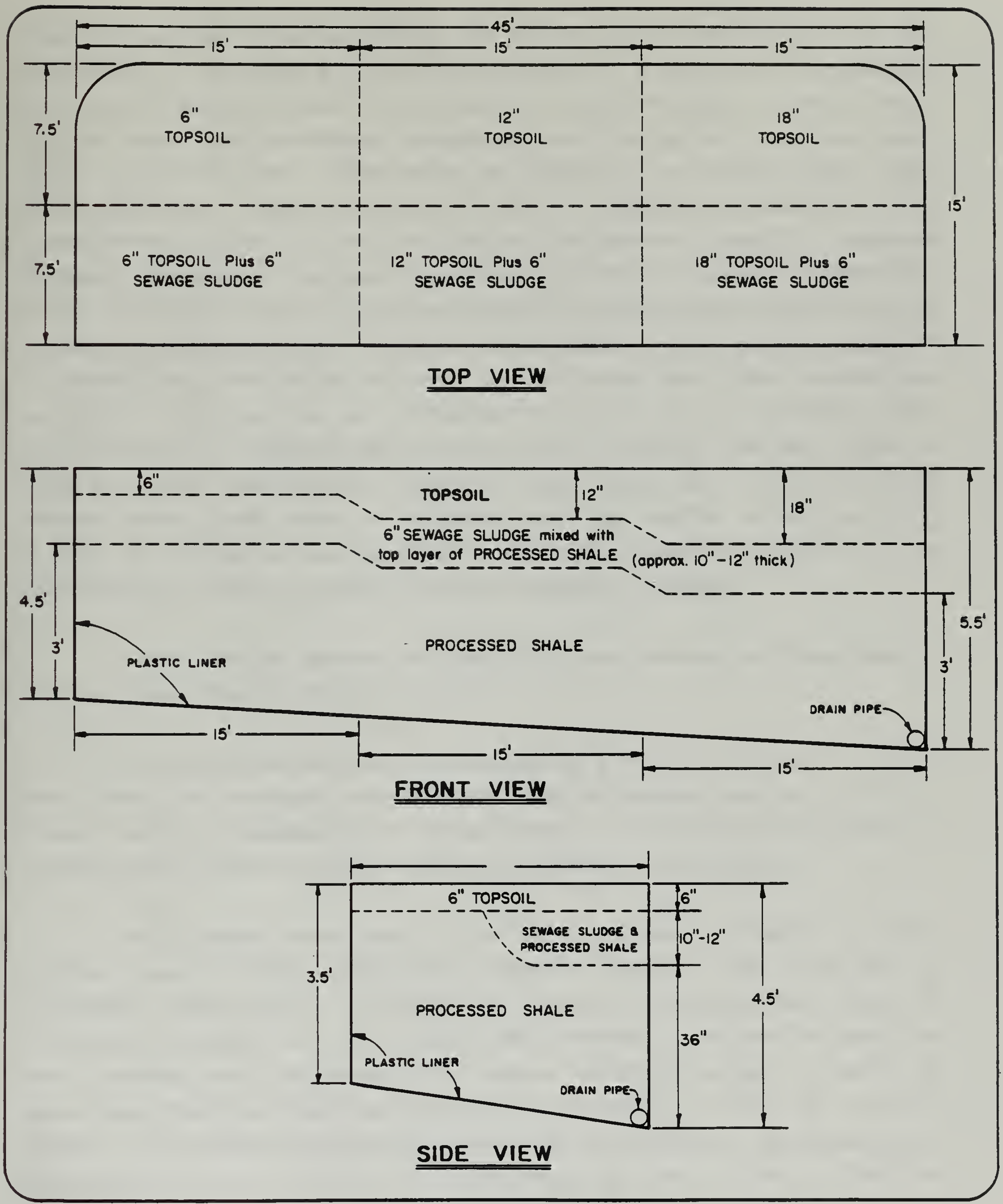
9.3.10.2.1 Processed Shale Demonstration Test Plot

The processed shale demonstration test plot study is designed to evaluate the effect of three different topsoil treatments and the effect of incorporating sewage sludge into the upper layer of the processed shale. This

shale was mined on the C-b Tract, sent to California and processed in a Union "B" retort. The test plot is located in an excavated portion of the rock disposal embankment southwest of the CB offices. The site was excavated in order to contain the processed shale and to allow for collection of leachate from the base of the test plots. Three sides of the plot were contained by the excavation into the rock disposal embankment. The fourth side was supported by a wall constructed of plywood supported by a rock and soil berm. Before the processed shale was placed in the excavated site, the bottom of the pit was sloped to one corner, the bottom was covered with a mixture of soil fines and bentonite clay, and then the entire plot (walls and bottom) was lined with a plastic liner. A plastic pipe was installed in the low corner to serve as a drain for collection of leachate. The drain extends under the retaining wall and berm and empties into a collection container.

The test plot is approximately 45 feet by 16 feet wide. The treatments in the plot were created by first placing approximately 60 tons of processed shale on the plot. When spread, the shale was approximately 3.5 feet thick. The processed shale was then fertilized with the equivalent of 100 pounds of available phosphorus per acre. The plot was then divided into equal halves along a north-south axis. On one half of the plot, a 6-inch layer of sewage sludge from the Glenwood Springs treatment plant was applied. The sludge was then mixed into the top 5-6 inches of the processed shale using a rototiller. The two halves of the plot were then divided into thirds and three different amounts of topsoil (6-inches, 12-inches, and 18-inches) were placed over the processed shale. This design produced six different treatments: 6-inches, 12-inches, and 18-inches of topsoil with 6-inches of sewage sludge incorporated into the processed shale; and 6-inches, 12-inches, and 18-inches of topsoil over processed shale with no sewage sludge. Each of the treatment blocks within the test plot is approximately 8-feet by 15-feet in size. The top of the processed shale was stepped in such a manner so as to keep the surface of the plot level and still incorporate the various sludge and topsoil depth treatments. A diagram of the plot is presented in Figure 9-25.

After the plot was covered with topsoil, the entire plot was fertilized with ammonium nitrate and blended phosphate at the rate of 100 pounds of available nitrogen per acre and 50 pounds of available phosphorus per acre.



PROCESSED SHALE DEMONSTRATION PLOT

Figure 9-25

The plot was then broadcast seeded; the species are listed in the July 1984 Data Report. The seeded plot was then mulched with a excelsior fiber matting. This type of mulch was used in an attempt to reduce the number of weedy annual species which tend to dominate revegetated areas during the first and second years at the CB site. After mulch was placed on the plot, nursery stock transplants were planted on each of the six different treatments. The transplanted species included serviceberry (Amelanchier alnifolia), mountain mahogany (Cercocarpus montanus), antelope bitterbrush (purshia tridentata), Wood's rose (Rosa woodsii), mountain snowberry (symphoricarpos oreophilus), and pinyon pine (Pinus edulis). The plot was irrigated using a sprinkle nozzle on a hydromulcher, saturating the plot to the extent that some leachate was collected. The purpose of irrigating the plot was to simulate winter precipitation. If the plot had been constructed in the fall the water added to simulate winter precipitation could have been eliminated. During the 1983 growing season, 8.25 inches of irrigation water was applied on the test plot. A total of 7-inches was applied prior to the time of vegetation sampling. The test plot was fenced to prevent grazing by domestic livestock.

Field sampling methods for vegetation were the same as those used in the raw shale demonstration test plot.

The production data were evaluated using a two-way analysis of variance which tests the hypothesis that no significant differences occur as a result of topsoil depth or introduction of sewage sludge. It also evaluates whether the interaction of sewage sludge and topsoil thickness is significant.

Soil samples were taken in the fall (October) following the first growing season. These samples were composite samples taken from the two treatments consisting of 12-inches of topsoil over processed shale and 12-inches of topsoil over the sewage sludge treatment. The sample depths for each treatment were; 0-6 inches, 6-12 inches, and 12-20 inches. A sample was also taken from the stockpiled topsoil used to cover the plot for use as a control. The samples were sent to a soils lab for analysis. The parameters in the analysis were: pH, ECe, CEC, SAR, NO_3, NH_4, PO_4, K, Na, B, Mo, and Cu.

The data for the vegetation and soil samples are contained in Vol. 3 of the January, 1984, Data Report.

On the plots treated with sewage sludge, mean total herbaceous cover varied somewhat among the three topsoil treatments. Mean total cover ranged from 72.5 percent on the 12-inch topsoil treatment to 61.5 percent on the 18-inch topsoil treatment. Mean cover on the 6-inch topsoil treatment was 70.75 percent. The major species are the perennial grasses, which were combined because of difficulties in identifying the individual species on the basis of vegetative characteristics. The perennial grasses accounted for 77 percent, 80 percent, and 68 percent of the total cover on the 6-inch, 12-inch, and 18-inch treatments, respectively. The other major species was Russian thistle (Salsola iberica) which accounted for most of the remaining cover on the three treatment blocks. As can be seen from the data, there is not a clear relationship between total cover and the depth of topsoil. On the plots not treated with sewage sludge, there was also no clear relationship between topsoil depth and mean total cover. Mean total cover ranged from 39.2 percent on the 18-inch treatment to 52.8 percent on the 12-inch treatment. Mean cover on the 6-inch treatment was 51.0 percent. As with the sewage sludge treatments, most of the cover was provided by perennial grasses in all topsoil treatments. Russian thistle was the only other species which contributed noticeably to the total cover.

In all treatments, most of the biomass was contributed by the perennial grasses and by Russian thistle. The biomass was divided approximately equally between these two groups. In the treatments with sewage sludge, mean total production was highest in the 18-inch treatment (281.3 g/m^2 - 2510 lbs/acre), followed by the 12-inch treatment (211.1 g/m^2 - 1883 lbs/acre) and the 6-inch treatment (199.3 g/m^2 - 1778 lbs/acre). The mean production values increase with increasing topsoil depth. In the treatments without sewage sludge, mean total production was highest in the 12-inch treatment (175.9 g/m^2 - 1569 lbs/acre) followed by the 18-inch treatment (148.8 g/m^2 - 1328 lbs/acre) and the 6-inch treatment (177.0 g/m^2 - 1044 lbs/acre). In these treatments, mean production did not exactly follow the topsoil gradient, however, the deeper

treatments had higher production. In all cases the treatments with sewage sludge had higher production than their corresponding treatments without sewage sludge. The significance of the differences among the different treatments was tested using a two-way analysis of variance. The results of the analysis (Table 9-12) show that the differences attributable to the sludge application were significant, and the differences attributable to topsoil thickness were also significant. The interaction of topsoil thickness and sewage sludge application was not significant. These results suggest that total production can be significantly increased by the application of sewage sludge and by increasing the depth of respread topsoil. These conclusions should be considered to be tentative, since approximately 50 percent of the total biomass in 1983 was attributable to annual forbs, mostly Russian thistle. It will be important to evaluate the treatments in subsequent years to see if the relationships noted in 1983 are consistent from year to year.

Any conclusions, concerning the success of revegetation on the plot, from the first years vegetation data would be premature. However, the production and cover values on the sewage sludge treated areas indicate that sewage sludge would be an effective growth medium amendment.

The high amounts of herbaceous production and cover of the plot are not expected to continue in the future, due to the moisture regime of the C-b Tract (the plot was irrigated throughout the first year). Therefore, some die-back of the plot is expected in subsequent years. This die-back, particularly the perennial grasses, will likely increase the number of forb and shrub species, thus increasing the diversity in future years. At this time, CB is encouraged by the results of the first year's data from this small demonstration plot.

Following is CB's interpretation of analyses of soils and processed shale parameters tested at the test plot:

Hydrogen Ion Concentration (pH) - ranges from 7.5-7.7 at the 0.6" depth and 7.2-8.3 at the 6-12" depth and 7.9-8.7 at the 12-20" depth and should not limit plant growth.

Table 9-12 Results of the Two-Way Analysis of Variance Test for Evaluating the Effects of Sewage Sludge Application and Topsoil Thickness on the Processed Shale Demonstration Plot. 1983 Data.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F	Significance*
Subgroups					
A Sludge	1	2083.17	2083.17	22.696	SIG
B Topsoil Thickness	2	660.47	330.23	3.598	SIG
Interactions					
A x B (Sludge x Topsoil Thickness)	2	472.81	236.41	2.576	NS
Within (Error)	114	10,463.48	91.78		
Total	119	13,679.93			

*SIG = Significant

*NS = Not Significant

$F_{0.05\ [1,114]} = 3.93$

$F0.05_{\ [2,114]} = 3.08$

Electrical Conductivity mmhos/cm - (ECe) is a test for levels of soluble salts of a saturation extract. ECe levels of 0.5-0.9 at the 6" depth and 2.2-4.5 at the 6-12" depth and 13-20 at the 12-24" depth should not limit plant growth because most plants obtain the majority of essential growth components from the upper 6" zone. Harbert III and Berg (1978), reported "Salts did not move up into the 30cm soil cover over TOSCO spent shale which was unleached and thus did not have a reservoir of water subject to capillary rise. The soluble salts have remained at the 30-60cm depths through the 1975 and 1976 growing seasons, apparently maintained at this depth by a balance between precipitation and evapotranspiration." Richards (1954), reported "Levels of 0-2 mmhos/cm should have negligible effects on plants." The distribution of soluble salts is similar to results as referenced, therefore, CB agrees with the conclusion that the salts will remain at lower depths.

Cation Exchange Capacity - (CEC) A level of 10-15 me/100g are moderate. The levels of 14-15 over retorted shale should not limit plant growth.

Sodium Absorption Ratio - (SAR) Levels in the top 12" levels of 2.5 to 4.5 should not be a limiting problem. Richards (1954) indicated low sodium hazards for 0-10 levels of SAR.

Nitrate - (NO_3) Results indicated a beneficial effect from sewage sludge. At depths of 6-12" NO_3 ranged from < 2 to 89; at 12 to 20" depths, NO_3 ranged from 1 to 220. In all cases, the higher readings were those associated with sewage sludge.

Nitrogen, Phosphorous, Potassium (N-P-K) - They are recognized as the primary plant food elements and will be added as necessary. Results indicate sewage sludge may have a positive effect on N and P. The demonstration plot was not fertilized with K and the results indicate a need to do so in the future.

Sodium (Na) - Sodium is discussed with the SAR evaluation.

Boron (B) - Levels for 0-12" depth were 0.8-1.0 ppm. Because toxic levels are 2.0-8.0 ppm (depending on plant species) no limiting effects are expected from boron.

Molybdenum and Copper (Mo, Cu) - These levels are not high or limiting for plant growth. The levels for 0-12" depth are within the range for native soils on C-b reported by Klusman (1979). Most problems encountered with these two elements are the results of a Cu:Mo ratio less than 2:1. CB has not found any instance (including the 12-20" retorted shale depth) of the Cu:Mo ratio being less than 2:1.

9.3.10.2.2 Spent Shale Leachate Studies

Leachate was produced following rainfall and initial irrigation of the plot. Samples were collected weekly when there was sufficient volume for analysis of all parameters. Design of the collection system precluded the collection of excess leachate or measurement of its volume. Collected samples were preserved and sent to the G-Road laboratory for analysis of the following parameters:

Al, As, Ba, B, Cd, Ca, Cr, Cu, Fe, Pb, Li, Mg, Mn, Hg, Mo, Ni, K, Se, Ag, Na, Sr, V, Zn, total Alkalinity, bicarbonate, carbonate, chloride, fluoride, nitrate, phenols, TDS, TSS, and DOC.

Table 9-13 lists the results of analysis of selected parameters.

No consistent trends are ascertainable except that some of the major ion concentrations appear to peak shortly after leachate formation through the pile. Higher initial nitrate concentrations are probably due to the application of ammonium nitrate as fertilizer.

Variability of leachate parameter concentrations may be due to changes in rates of precipitation and irrigation, changes in ambient temperature and resulting shifts in solubility equilibria. It is expected that reduction in concentration of most species will continue as successive pore volumes leach through the pile.

RESULTS OF 1983 ANALYSIS OF SPENT SHALE DEMONSTRATION PLOT LYSIMETER LEACHATE

DATE	Ca	Mg	Na	K	SO_4	Cl	HCO_3	NO_3	TDS	ECe umhos
5-12	2.5	2.2	-	-	6,500	1,400	1,800	-	16,000	23,300
5-19	2.5	9.9	10,000	200	8,500	4,100	1,000	22	24,000	28,600
5-23	0.8	3.5	12,000	230	-	3,900	2,800	23	33,000	36,300
6-14	8.7	26.0	2,700	44	480	380	720	0.5	7,900	11,900
6-27	7.6	44.0	2,000	160	120	420	930	<0.5	17,000	22,900

DATE	B	Si	Mo	Mn	Ni	Al	Sr	F	Zn
5-12	1.7	3.0	-	-	-	27.0	-	18.0	-
5-19	1.8	3.1	4.0	.02	0.5	26.0	<0.5	20.0	.05
5-23	3.8	1.0	4.7	.08	0.6	34.0	<0.5	21.0	.05
6-14	1.8	1.0	1.4	<.02	0.5	3.0	0.5	9.9	<0.02
6-27	2.6	0.7	7.9	0.2	1.0	0.8	0.5	16.0	.05

Parameter concentrations are in mg/l.

DATE	As	Ba	Cd	Cr	Hg	Pb	Ag	Se	pH
5-12	-	-	-	-	-	-	-	-	10.40
5-19	0.3	18.0	.06	0.1	<0.0002	1.0	0.07	<0.01	10.25
5-23	0.3	38.0	.08	0.1	<0.0002	0.9	0.2	<0.01	10.22
6-14	0.03	<0.5	.01	0.02	<0.0002	0.06	0.02	<0.01	9.46
6-27	0.03	<0.5	.02	0.3	<0.0002	0.03	0.05	0.04	9.40

9.3.10.3 <u>Topsoil Storage Embankments</u>

Four topsoil storage embankments were sampled for species composition, vegetative cover, and herbaceous production. The methods used in conducting this sampling were the same as those used in earlier years for sampling in the four major vegetation communities on Tract.

Two of the topsoil embankments were in their fifth growing season. The topsoil in these embankments came from the mine and support facilities areas. These embankments were seeded, straw mulched, and fenced in the fall of 1978. The species seeded and the rates of seeding are listed in the July 1984 Data Report. Seeding was completed with a rangeland drill. These embankments are labeled as the northwest stockpile and the southernmost stockpile.

The other two embankments were in their third growing season. This topsoil came from the area where the raw shale stockpile is presently located. These embankments were seeded with a rangeland drill (species and rates of seeding are listed in the July 1984 Data Report), hydromulched, and fenced in the fall of 1980. These embankments have been labeled as the E/S shed stockpile and the fabrication shop stockpile.

The objectives of sampling these embankments are two fold: 1) to demonstrate the revegetation potential of disturbed sites, and 2) determine the effects of cattle grazing on revegetated sites, as concerns species composition (particularly shrub densities) and production. We feel that recontoured, retopsoiled, and revegetated disturbed sites, (which are areas of disturbance not associated with raw or processed shale disposal), should be expected to have revegetation potentials similar to these topsoil embankments. Two of the four stockpiles will be opened to allow cattle grazing in the spring of 1984. These two will consist of one each of the different aged piles.

Data from the stockpile embankments are contained in the January, 1984, Data Report.

The estimated total herbaceous cover for the northwest pile (fifth growing season) was 30.35 percent with mean number of species per-square-meter of 5.5. Mean shrub cover was 0.76 percent with an estimated density of 429 individuals per hectare. The mean total herbaceous production was 232.1 grams/m^2 (2071 lbs/acre) dry weight. This is three times the amount of production which was found in the range cages in the chained rangeland vegetation type. Most of the herbaceous cover and production was attributed to the wheatgrasses. Cicer milkvetch was the dominant forb. The majority of the shrub species ranged from 0.26-0.75 meters in height.

The southernmost pile (fifth year) had a herbaceous cover value of 40.6 percent with 4.6 species/m^2. Shrub cover was estimated at 0.98 percent with an estimate of 1,040 individuals per hectare. Herbaceous production was estimated at 248 grams/m^2 (2213 lbs/acre). The dominant species were the same as above.

The Environmental Services' shed pile (third year) had a herbaceous cover value of 36.85 percent with 6.45 species /m^2. Shrub cover was less than 0.01 percent with 1077 individuals per acre. The majority of shrubs were seedlings which were less than 0.25 meters in height. Total herbaceous production was 221.1 grams/m^2 (1973 lbs/acre). The major species were the wheatgrass and alfalfa.

The fab shop pile (third year) had a herbaceous cover value of 47.95 percent with a mean number of species per m^2 of 8.4. Shrub cover was less than 0.01 percent with an estimate of 565 individuals per acre. Total herbaceous production was 252.5 grams/m^2 (2253 lbs/acre.) The major secies are the same as above.

9.3.11 Special Projects

9.3.11.1 Sprinkler-Irrigation System Impacts

The sprinkler-irrigation system which was used to dispose of excess mine water during the growing seasons of 1980 and 1981 has not been used the last two years. However, the concentration and build-up of salts and specific

ions in soils and vegetation from the water applied during the two seasons of operation does not necessarily disappear once irrigation ceases. Therefore, a chemical analysis of the soils and vegetation was conducted in October 1982 in order to determine the concentration levels of salts and ions in the soils and vegetation one year following irrigation. The results of this analysis have been presented in the January 15, 1983 Environmental Monitoring Report.

The results of the 1982 analysis concluded that the concentrations of parameters in the soil and vegetation were, for the most part, significantly below toxic concentrations and were not considered to be of concern. However, since there were slight increases in some parameters observed in 1982 it was decided to do a limited amount of sampling and analysis in 1983.

The 1983 sampling was conducted in October for both vegetation and soils. Sampling was limited to areas designated as treatment 5b and the Control Area. Treatment area 5b was chosen because it received the same amounts of irrigation, the same duration of irrigation, and the same repetitions of irrigation as the entire irrigated area. The 1983 data from the sampling and analysis have been presented in the January, 1984 Data Report.

9.3.11.2 Chemical Analysis

The soil parameters analyzed were pH, electrical conductivity (EC_e), exchangeable sodium percentage (ESP), and boron (B). The vegetation parameters analyzed were fluoride, boron, and sodium. In order to determine the status of parameters in the soil and vegetation concerning toxic and increasing or decreasing concentrations since irrigation has terminated, three questions have been asked:

1) Are 1983 levels less than what could be considered toxic concentrations for plant growth and/or for animals which consume the plants? Toxicity criteria for soils and vegetation are listed in Tables 9-14 and 9-15, respectively.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

TABLE 9-14

Soil Toxicity Criteria for pH, Electrical Conductivity (EC_e), Boron (B) and Exchangeable Sodium Percentage (ESP)

--pH	Soil pH less than 9.0 is considered suitable for plant growth. A pH greater than 9.0 may impede plant growth (Buckman, H. O., and N. C. Brady. 1969. The Nature and Properties of Soils. Macmillan Co., New York, N.Y., 653p.).
--EC_e:	EC_e of less than or equal to 2.0 mmhos/cm may cause a slight yield reduction only in the more sensitive forage crops (Mass, E. V. and G. J. Hoffman. 1977. Crop Salt Tolerance--Current Assessment. J. Irrig. and Drainage Div., Amer. Soc. Civil Engr. 00: 115 - 134).
--Boron:	Boron concentrations greater than or equal to 2.0 ppm can cause damage to sensitive crops (Maas and Hoffman, 1977).
--ESP:	Moderately tolerant crops can grow with little or no loss in production in soils which have an ESP of 20-40%. This is also the level where physical structure of the soils is too poor for good crop production (Ayers, R. S. and D. W. Westcot. 1976. Water Quality for Agriculture. Irrigation and Drainage Paper No. 29. Food and Agriculture Organization of the U. N. Publication. 97p.).

TABLE 9-15

<u>Vegetation Toxicity Criteria for Fluoride (F), Boron (B), and Sodium (Na)</u>

--Fluoride: Fluoride toxicosis has been observed in livestock grazing western wheatgrass containing 60 ppm F. (Shupe, J. L., H. B. Peterson, Arland E. Olse, and Gene W. Miller. 1978. Effects of Poisonous Plants on Livestock. Academic Press, Inc., New York, N.Y., 40p.)

--Boron: Concentrations of B which are greater than 250 ppm can cause boron leaf toxicity. (L. A. Richards. 1954. Diagnosis and Improvements of Saline and Alkali Soils. USDA Agricultural Handbook No. 60.)

--Sodium: Concentrations of Na in plant foilage of 10 - 30 meq NaCl per 100 grams, or 2300 - 6900 ppm Na was found to be toxic for sodium sensitive plants. (Ehlig, C. F. and L. Bernstein. 1959. Foliar Absorption of Sodium and Chloride as a Factor in Sprinkler Irrigation. Proc. Amer. Soc. Hort. Sci. 74: 661-670.)

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

2) Are 1983 concentrations in the soil less than those for 1982 (since irrigation has ceased, the levels would be expected to continue to decrease); and, have 1983 concentrations in vegetation decreased from 1982 levels?

3) Is there a difference between 1983 levels in treatment 5b (described in previous reports) vs. the control area? This comparison helps eliminate environmental variability factors (such as climate) which may be different from one year to the next. The summaries of analysis and the results of comparisons are presented in Tables 9-16, 9-17, and 9-18.

Results of 1983 sampling and analysis indicate that the concentrations of all parameters tested for both the soils and vegetation are significantly less than toxic levels. With the exception of electrical conductivity, there are no significant differences between 1983 and 1982 concentrations in the soils. Conductivity was significantly less in 1983. Sodium concentrations in the vegetation were much higher in 1983. It is not known why the sodium concentrations were this high. Since all the individual samples showed high concentrations this is likely a result of natural conditions; however, it is possible that something occurred in sampling or the laboratory analysis that caused the high concentrations. In any event, CB feels that the high concentrations of sodium in the vegetation are not a result of irrigation since both the treatment and control area had high levels. However, CB personnel will collect vegetation samples in October 1984 and have these samples analyzed for sodium content.

9.3.12 Ecosystem Interrelationships

Ecosystem interrelationship studies are continually being conducted for three reasons: 1) to determine the potential impact of environmental perturbations resulting from development activity, 2) to quantify relations between biotic and abiotic variables, and 3) to select and evaluate variables for interrelationships themselves.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

TABLE 9-16

Average Fluoride (F), Boron (B), and Sodium (Na) Concentrations in Foliage of *Agropyron smithii* and *Artemsia tridentata* at the end of Growing Seasons 1980, 1981, 1982, and 1983. Vegetation samples taken from areas designated as Treatments 5b and Control of the 1980 and 1981 irrigation area.

SPECIES	TREATMENT #	1980	1981	1982	1983
			Fluoride (ppm)		
Agropyron smithii	5b	27.6	19.0	< 20	< 5[a]
	Control	--	23.8	< 20	< 5[a]
Artemsia tridentata	5b	8.8	13.2	< 20	< 5[a]
	Control	--	10.4	< 20	< 5[a]
			Boron (ppm)		
Agropyron smithii	5b	40.4	2.5	23.4	31[a]
	Control	--	2.2	14.5	29[ab]
Artemisia tridentata	5b	113.0	87.6	44.0	28[ab]
	Control	--	21.6	34.8	33[a]
			Sodium (ppm)		
Agropyron smithii	5b	455.1	354.4	258.0	738[ab]
	Control	--	212.8	127.6	780[ab]
Artemisia tridentata	5b	663.5	214.7	132.0	1,036[ab]
	Control	--	57.9	157.0	1,014[ab]

a 1983 concentrations of F, B, and Na were compared with known toxic concentrations of F, B, and Na in vegetation foliage. Those values followed by an "a" are significantly below toxic concentrations at $\alpha = 0.05$ using the t Test.

b 1983 concentrations were compared to 1982 concentrations. 1983 values followed by a "b" are significantly different than 1982 concentrations at $\alpha = 0.05$ using the t Test.

TABLE 9-17

Average of pH and Electrical Conductivity (EC_e) of Soil Samples taken June and December 1980, October 1981, 1982 and 1983

TREATMENT NUMBER	DEPTH (ft.)	pH					EC_e (mmhos/cm)				
		JUN80	DEC80	OCT81	OCT82	OCT83	JUN80	DEC80	OCT81	OCT82	OCT83
5a	0-1	7.7	8.4	8.7	8.0	---	1.0	1.1	1.9	1.7	---
	1-2	---	---	8.5	7.9	---	0.7	---	1.4	1.4	---
5b	0-1	7.8	8.3	8.7	8.0	7.98[a]	0.9	0.8	1.2	1.4	0.92[abc]
	1-2	7.8	---	8.4	7.9	7.8[a]	0.7	---	0.9	1.3	0.87[ab]
	2-2.5	8.1	---	8.4	7.7	---	0.7	---	0.9	1.0	---
5c	0-1	7.3	8.2	8.5	8.0	---	0.4	1.0	0.8	0.8	---
	1-2	7.8	---	8.3	7.7	---	0.4	---	0.8	0.7	---
7c	0-1	7.9	8.4	8.7	7.9	---	0.6	0.6	1.0	2.7	---
	1-2	8.1	---	8.6	7.7	---	1.1	---	1.1	2.9	---
control	0-1	---	---	7.9	7.5	7.63[a]	---	---	0.8	0.7	0.47[ab]
	1-2	---	---	8.2	7.6	7.57[a]	---	---	0.5	0.5	0.52[a]

[a] 1983 levels followed by an "a" are significantly less than toxic levels of respective parameter at $\alpha = 0.05$ using the t Test.

[b] 1983 levels followed by a "b" are significantly less than respective 1982 levels at $\alpha = 0.05$ using the t Test.

[c] 1983 Treatment 5b level followed by a "c" are significantly different than 1983 Control levels for same depths and parameters at $\alpha = 0.05$ using the t Test.

TABLE 9-18

Average of Exchangeable Sodium Percentage (ESP), and Boron of soil samples taken June and December 1980, October 1981, 1982 and 1983

TREATMENT NUMBER	DEPTH (ft.)	ESP (%)					Boron (ppm)				
		JUN80	DEC80	OCT81	OCT82	OCT83	JUN80	DEC80	OCT81	OCT82	OCT83
5a	0-1	< 1	8.0	12.8	14.2	---	0.8	0.9	0.3	2.1	---
	1-2	< 1	---	9.3	11.2	---	0.6	---	<0.1	1.2	---
5b	0-1	< 1	6.0	10.0	15.3	9.08[abc]	1.1	0.4	0.3	2.1	3.83[c]
	1-2	< 1	---	3.0	10.9	5.15[ab]	0.6	---	<0.1	1.1	1.95
	2-2.5	< 1	---	3.0	6.7	---	0.8	---	---	1.1	---
5c	0-1	< 1	5.8	6.8	9.3	---	0.3	0.8	0.5	0.9	---
	1-2	< 1	---	2.3	3.4	---	0.3	---	0.2	0.5	---
7c	0-1	1.8	7.8	6.5	9.8	---	0.7	0.6	0.8	1.9	---
	1-2	7.3	---	3.0	12.3	---	1.8	---	0.4	2.6	---
control	0-1	---	---	1.8	3.1	1.33	---	---	<0.1	0.9	1.24
	1-2	---	---	1.0	1.3	2.95	---	---	<0.1	0.9	0.80[a]

[a] 1983 levels followed by an "a" are significantly less than toxic levels of respective parameter at $\alpha = 0.05$ using the t Test.

[b] 1983 levels followed by a "b" are significantly less than respective 1982 levels at $\alpha = 0.05$ using the t Test.

[c] 1983 Treatment 5b level followed by a "c" are significantly different than 1983 Control levels for same depths and parameters at $\alpha = 0.05$ using the t Test.

9.3.12.1 A Prelimimary Deer Road Kill Model

The objective to developing a preliminary model of deer road kills was to attempt to identify some of the causal factors involved. If successful, the model could suggest ways to lessen hazards to motorists as well as decrease deer mortalities.

Development of the model as begun by an examination of the existing Tract C-b data base. Monitoring programs over the past five years were gleaned for information that might possibly relate to deer road kills. Using this information the following data sets were selected for analysis:

- Deer road counts (from Rio Blanco to the White River),
- Herd size (CDOW annual estimates for Game Management Unit (GMU) No. 22),
- Deer pellet-group counts (Tract C-b),
- Bitterbrush utilization (Tract C-b),
- Traffic volume (number of vehicles traveling the Piceance Creek road),
- Snow depth (Tract C-b),
- Average temperature (Tract C-b),
- Precipitation (Tract C-b).

The above eight data sets were used as predictor variables in a multiple regression (MR) model. Number of road kills was used as the response variable. All data were arranged for two-week blocks extending from

mid-September to mid-May (the time that deer are wintering in the Tract C-b area). This resulted in a sample size consisting of 54, two-week periods.

The multiple regression of all eight predictor variables (Table 9-19) resulted in a multiple correlation coefficient, R^2 = 0.413, which is highly significant (P = .002). Therefore, in terms of this particular eight-predictor case, approximately 41 percent of the variance in deer road kills is explained by the full eight-predictor model. Stepwise elimination (also shown in Table 9-17) resulted in a final four-predictor model. The four predictors identified as as most important were: road counts, herd size, precipitation, and bitter-brush utilization. R^2 remained high after four-predictors were eliminated, with approximately 40 percent of the variance still being explained. This small decline in R^2 was accompanied by a marked increase in statistical significance ($P < .005$).

Probably the most surprising result of the MR analysis is the absence of the variable, traffic volume, in the final model. Traffic volume, however, was almost retained, dropping out of stepwise elimination at the last step (see Table 9-19). The failure of the model to single out traffic volume is probably due to the strong negative correlation (r = -0.49) between traffic volume and herd size (see the simple correlation matrix in Table 9-19). Traffic volume tended to be lowest when herd size was highest. Negative correlations also can be seen between three additional variables (all of which reflect herd size) and traffic volume: road counts, pellet-group counts, and bitterbrush utilization.

It is not surprising that road counts and herd size were singled out by the MR analysis as being importantly related to frequency of road kills. In contrast, a causal connection between precipitation and road kills seems questionable. However, it should be noted that the variance contribution of precipitation is not statistically significant (R^2 = 0.048; F = 3.89). The rationale for retaining precipitation in the model was based on the drop in R^2 that occurs when it is removed. The resulting three-predictor model has an R^2 = 0.350, which amounts to an appreciate decline in the overall explanatory power of the final model. The tentative conclusion suggested here regarding precipitation is that precipitation could possible influence the probability of road kills, but further verification is needed.

[illegible]

[illegible]

[illegible]

[illegible]

TABLE 9-19

Preliminary Deer Road Kill Model, Multiple Regression Analysis [1]

SIMPLE CORRELATIONS (r) OF ROAD KILLS WITH EIGHT PREDICTOR VARIABLES:

		RK	RC	HS	TV	SN	AT	PT	PG	BU
No. Road Kills	RK		.51*	.20	-.13	-.19	-.10	.29*	.06	-.22
Road Counts	RC			.08	-.19	.13	-.01	.11	.20	-.22
Herd Size	HS				-.49*	.32*	-.17	.20	-.32*	.56
Traffic Volume	TV					-.27*	.09	-.25	-.04	-.18
Snow Depth	SN						-.49*	.04	-.15	-.17
Average Temp.	AT							-.06	-.03	-.01
Precipitation	PT								.06	.10
Pellet-groups	PG	n = 54								-.30*
Bitterbrush Utilization	BU	r (.05) = 0.268								

MULTIPLE REGRESSION AND STEPWISE ELIMINATION:[2]

	Full Model		Step 2 Omit PG		Step 2 Omit SN		Step 3 Omit AT	
	R^2(%)	F	R^2(%)	F	R^2(%)	F	R^2(%)	F
RC	14.1	10.77*	14.1	11.07*	14.3	11.39*	14.2	11.54*
HS	5.6	4.29*	6.1	4.08*	6.5	5.21*	7.1	5.78*
TV	1.0	0.73	1.1	0.86	1.2	0.96	1.2	0.99
SN	0.2	0.12	0.1	0.10				
AT	0.3	0.22	0.3	0.20	0.1	0.11		
PT	5.3	4.09*	5.3	4.14*	5.4	4.33*	5.5	4.45*
PG	0.1	0.05						
BU	6.3	4.84*	6.3	4.91*	6.8	5.41*	7.1	5.77*
	R^2 = 0.413		R^2 = 0.412		R^2 = 0.411		R^2 = 0.410	
	F = 3.96*		F = 4.61*		F = 5.47*		F = 6.66*	

	Step 4 Omit TV	
	R^2 (%)	F
RC	13.4	10.87*
HS	5.9	4.80*
TV		
SN		
AT		
PT	4.8	3.89
PG		
BU	6.7	5.41*
	R^2 = 0.398	
	F = 8.09*	

* Significant at the 95 percent level (α = 0.05).

1 Sample size (n = 54) is based on 2-week time periods (mid-September through mid-May) from 1977-78 through 1982-83.

2 R^2 (%) = reduction in R^2 due to removing the predictor; F = significance test.

[illegible]

The last predictor, bitterbrush utilization, is of interest in that its correlation with road kills is negative (the sign remaining unchanged throughout stepwise elimination). It should be noted that bitterbrush utilization is positively correlated with herd size (r = 0.56). Thus, bitterbrush utilization on Tract C-b appears to reflect regional levels of deer abundance. A possible explanation for the negative correlation of bitterbrush utilization with road kills is that during deep-snow years (which correlate with low bitterbrush utilization on Tract C-b, r = -0.17) deer are likely to be forced to lower-elevation agricultural meadows and south-facing slopes, both of which are in close proximity to the Piceance Creek road. Snow depth, therefore, may be more important to road kills than the final model would suggest.

In summary, the MR model of deer road kills that was developed integrated a diverse set of data in a quite successful way. The predictor variables linked to road kills seem entirely reasonable. These were: 1) road counts (number of deer counted in close proximity to the road); 2) herd size (regional abundance of deer); and 3) bitterbrush utilization as influenced by snow depth. The amount of precipitation may be involved, but this is uncertain. Traffic volume also is to be considered important; this predictor was not singled out by the analysis, probably because of the coincidence of high traffic volumes occurring during years of low numbers of deer.

9.3.13 Items of Aesthetic, Historic, or Scientific Interest

Surface activity was limited in 1983 so that minimum impact on aesthetics occurred. Good "housekeeping" is monitored by regular site inspections of the OSPO and by consistent alertness of the environmental on-site staff.

9.3.14 Health and Safety

Accident frequency analyses are included in the semi-annual data reports to the OSPO. At C-b, based on 156,135 man-hours, there were two lost-time accidents. The site injury (incident) rate in 1983 was 2.56 (reportable accidents x 200,000/man-hours). This compared with five lost-time accidents in 1982, and an injury rate of 3.10.

9.3.15 Toxicology

Toxicological testing has been curtailed due to reduced on-site activity. A continuation of the toxicological program is being planned for the future.

9.3.16 Data Management and Quality Assurance

Air data are incorporated in a computerized data base management system called RAMIS. The basic data report generated is a diurnal table of hourly-average values for each variable, excepting particulates which are measured every fourth day as a daily total. Monthly air reports are generated and incorporated in six-month data reports along with summary tables and graphs. Hourly values are also stored on a tape supplied to the OSPO; see Table 9-20.

Regarding quality assurance for air data, daily zero-and span-checks are made to check for potential drifts. Monthly multipoint calibrations are made for all gaseous data. Third party quarterly audits (see discussion in Section 9.3.5) and data precision checks (see most recent data report) are part of the quality assurance program.

Water data are also incorporated in RAMIS, excepting streams data which are stored in the USGS WATSTOR data base and interrogated by the Project's computer dial-up. Values are then incorporated into the 6-month data reports to the OSPO and put on tapes as indicated in Table 9-20.

Innovations on water data sampling techniques for deep wells instituted in May 1982 include the compressed gas driven samplers (Bar Cad System) for water quality, replacing swabbing, pumping and/or bailing and lineal, distributed-resistance water level sensors replacing conventional electric probes on electric reels. Such improvements enhance the quality assurance aspects of the water quality program since the samples are much less likely to be contaminated by pipe scale, joint lubricant and suspended solids attendant with the swabbing process. Additionally, the water quality data base is undergoing statistical examination for outliers.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

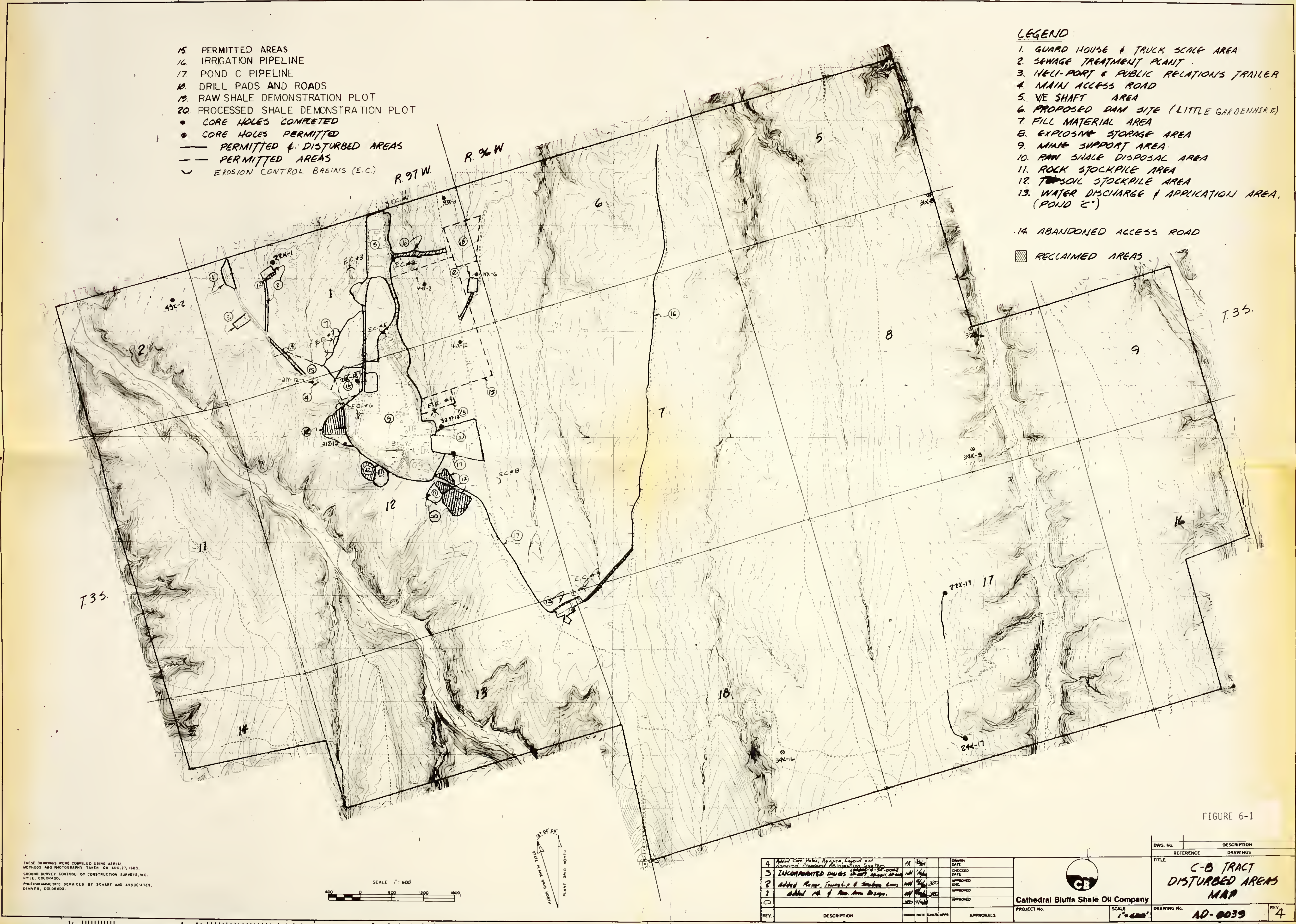
TABLE 9-20

Status of the Automated Environmental Data Base

HYDROLOGY AND WATER QUALITY	
Water Quality	
Springs and Seeps	October 1974 thru November 1981
Alluvial Wells	October 1974 thru November 1981
Deep Bedrock Wells	October 1974 thru November 1983
Field Measurements	
Springs and Seeps	October 1974 thru February 1984
Alluvial Wells	October 1974 thru November 1981
Deep Bedrock Wells	October 1974 thru February 1984
Levels and Flows	
Well Levels	October 1974 thru January 1984
Spring Flows	October 1974 thru February 1984
Water Augmentation Plan	
Springs and Seeps	July 1979 thru January 1984
Deep Bedrock Wells	August 1979 thru January 1984
Precipitation	January 1979 thru November 1983
National Pollutant Discharge Elimination System	
Water Quality Data	July 1979 thru February 1984
Water Usage	June 1980 thru February 1984
Well Reinjection	March 1981 thru June 1982 (Discontinued)
Streams	June 1982 thru June 1983
AIR QUALITY	
Air Quality Trailer AB23	October 1974 thru February 1984
Trailer AB20	October 1974 thru January 1982
Trailer AB26	October 1981 thru March 1982
Meteorological Tower AA23	October 1974 thru February 1984
Weather Station AD20	February 1982 thru July 1982
Station AD42	October 1974 thru March 1982
Station AD56	October 1974 thru August 1980
VISIBILITY	
Telephotometric	September 1975 thru October 1983
Photographic (Discontinued)	September 1975 thru October 1982
Traffic	February 1980 thru January 1984
Biology	
Microclimate	October 1974 thru March 1984
Deer Kill	October 1977 thru January 1984
Deer Count	September 1977 thru January 1984
Avifauna	1977 thru 1981

9.3.17 Reporting

Annual reports are submitted to the OSPO during the anniversary month of the Lease (April). Semi-annual Data Reports are submitted on January 15 and July 15. Air quality data volumes in these reports are also submitted to EPA, Region VIII, and the Air Quality Control Division of the Colorado Department of Health. Hydrologic data have been forwarded to the USGS in Denver to provide additional inputs for the regional groundwater modeling development.



LEGEND:
1. GUARD HOUSE & TRUCK SCALE AREA
2. SEWAGE TREATMENT PLANT
3. HELI-PORT & PUBLIC RELATIONS TRAILER
4. MAIN ACCESS ROAD
5. V/E SHAFT AREA
6. PROPOSED DAM SITE (LITTLE GARDENHIRE)
7. FILL MATERIAL AREA
8. EXPLOSIVE STORAGE AREA
9. MINE SUPPORT AREA
10. RAW SHALE DISPOSAL AREA
11. ROCK STOCKPILE AREA
12. TOPSOIL STOCKPILE AREA
13. WATER DISCHARGE & APPLICATION AREA. (POND "C")
14. ABANDONED ACCESS ROAD
15. PERMITTED AREAS
16. IRRIGATION PIPELINE
17. POND C PIPELINE
18. DRILL PADS AND ROADS
19. RAW SHALE DEMONSTRATION PLOT
20. PROCESSED SHALE DEMONSTRATION PLOT
CORE HOLES COMPLETED
CORE HOLES PERMITTED
PERMITTED & DISTURBED AREAS
PERMITTED AREAS
EROSION CONTROL BASINS (E.C.)
RECLAIMED AREAS
R. 97 W.
R. 96 W.
T. 3 S.
THESE DRAWINGS WERE COMPILED USING AERIAL METHODS AND PHOTOGRAPHY TAKEN ON AUG. 27, 1980.
GROUND SURVEY CONTROL BY CONSTRUCTION SURVEYS, INC. RIFLE, COLORADO.
PHOTOGRAMMETRIC SERVICES BY SCHARF AND ASSOCIATES, DENVER, COLORADO.
SCALE 1" = 600'
STATE PLANE GRID NORTH
PLANT GRID NORTH
4 Added Core Holes, Revised Legend and Removed Proposed Reinjection System
3 INCORPORATED DWGS.
2 Added Range, Township & Section Lines
1 Added ... & Res. Area Design.
0
REV. DESCRIPTION DATE CHK'D APPR. APPROVALS
DRAWN DATE
CHECKED DATE
APPROVED ENG.
APPROVED
APPROVED
Cathedral Bluffs Shale Oil Company
PROJECT No.
SCALE
DWG. No. DESCRIPTION
REFERENCE DRAWINGS
TITLE
C-B TRACT DISTURBED AREAS MAP
DRAWING No. AD-0039
REV. 4

FIGURE 6-1

1
2
3
4
5
A
B
C
230
231
E. 1,232,000
233
234
235
E. 1,236,000
237
238
239
E. 1,240,000
241
242
243
E. 1,244,000
245
188
187
186
185
184,000
183
FIGURE 4-3
FIGURE 4-5
FIGURE 4-2

3
4
5
6
7
A
B
C
237
238
239
E. 1,240,000
241
242
243
E. 1,244,000
245
246
247
E. 1,248,000
249
FIGURE 4-5

FIGURE 4-5
FIGURE 4-3
FIGURE 4-2
FIGURE 4-4
188
187
186
185
184,000
183
182
181
180,000
179
178
177
176
C
D
E
THESE DRAWINGS WERE COMPILED USING AERIAL METHODS AND PHOTOGRAPHY TAKEN ON AUG.27, 1980.
GROUND SURVEY CONTROL BY CONSTRUCTION SURVEYS, INC. RIFLE, COLORADO.
PHOTOGRAMMETRIC SERVICES BY SCHARF AND ASSOCIATES, DENVER, COLORADO.
SCALE 1" = 600'
600 0 600 1200 1800
18° 00' 05"
STATE PLANE GRID NORTH
PLANT GRID NORTH
1 GRID & FIGURE Areas Outlined
REV.
DESCRIPTION

DWG. No.	DESCRIPTION
AD-0018	AREA MASTER INDEX

REFERENCE DRAWINGS

REV.	DESCRIPTION	DRAWN	DATE	CHK'D	APPR	APPROVALS
1	GRID & FIGURE Areas Outlined	VS	4/1/82			

DRAWN DATE
CHECKED DATE
APPROVED ENG.
APPROVED
APPROVED

Cathedral Bluffs Shale Oil Company

TITLE
FIGURE 4-1
C-b TRACT
TOPOGRAPHIC MAP

PROJECT No. ESF-13.3
SCALE 1" = 600'
DRAWING No. AD-0017
REV. P